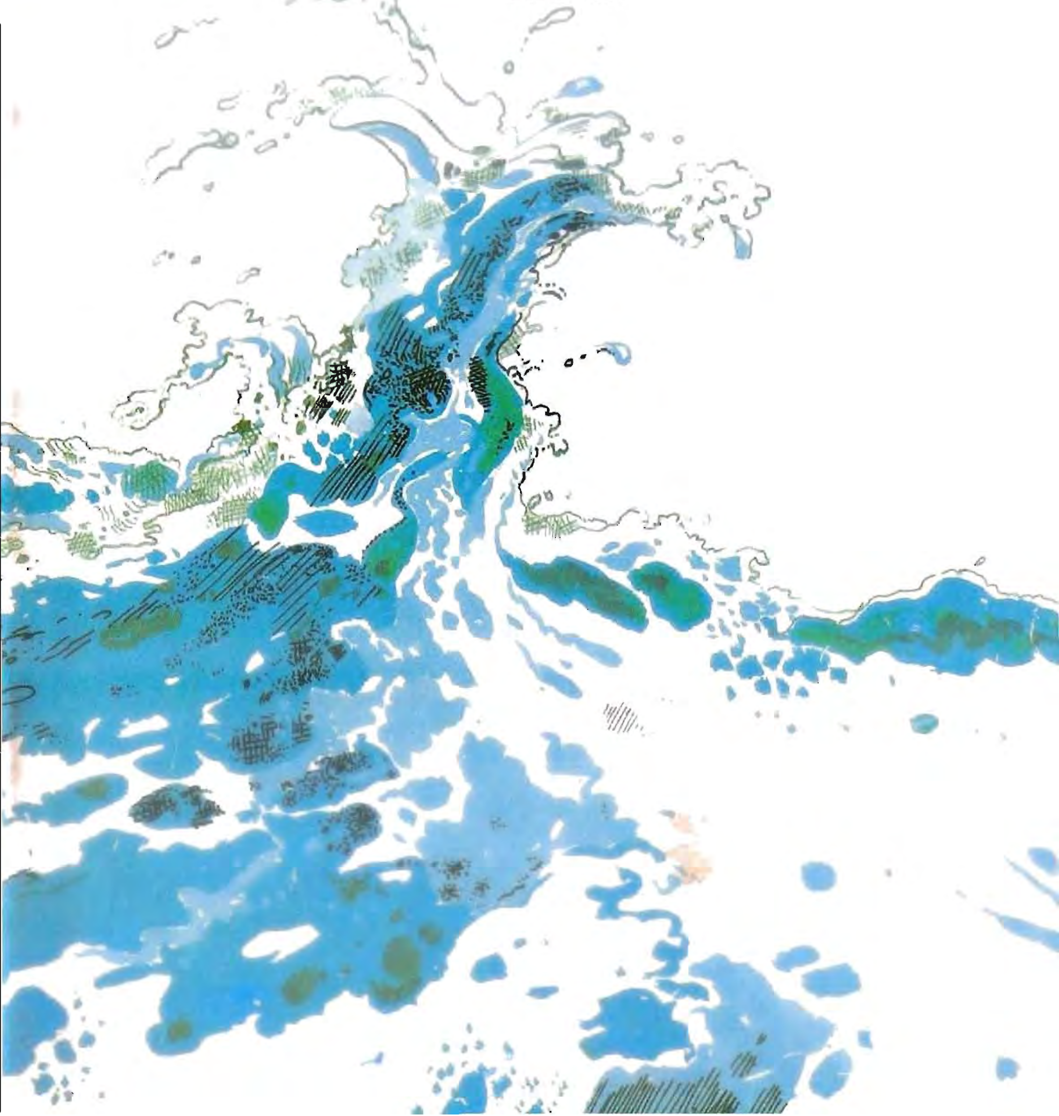
NEHRU BAL PUSTAKALAYA

WATER

RAMA



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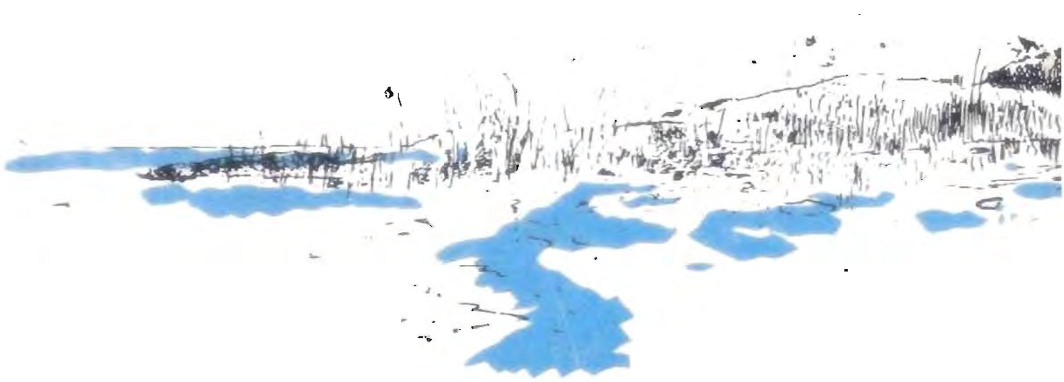

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Suddhasattwa Basu

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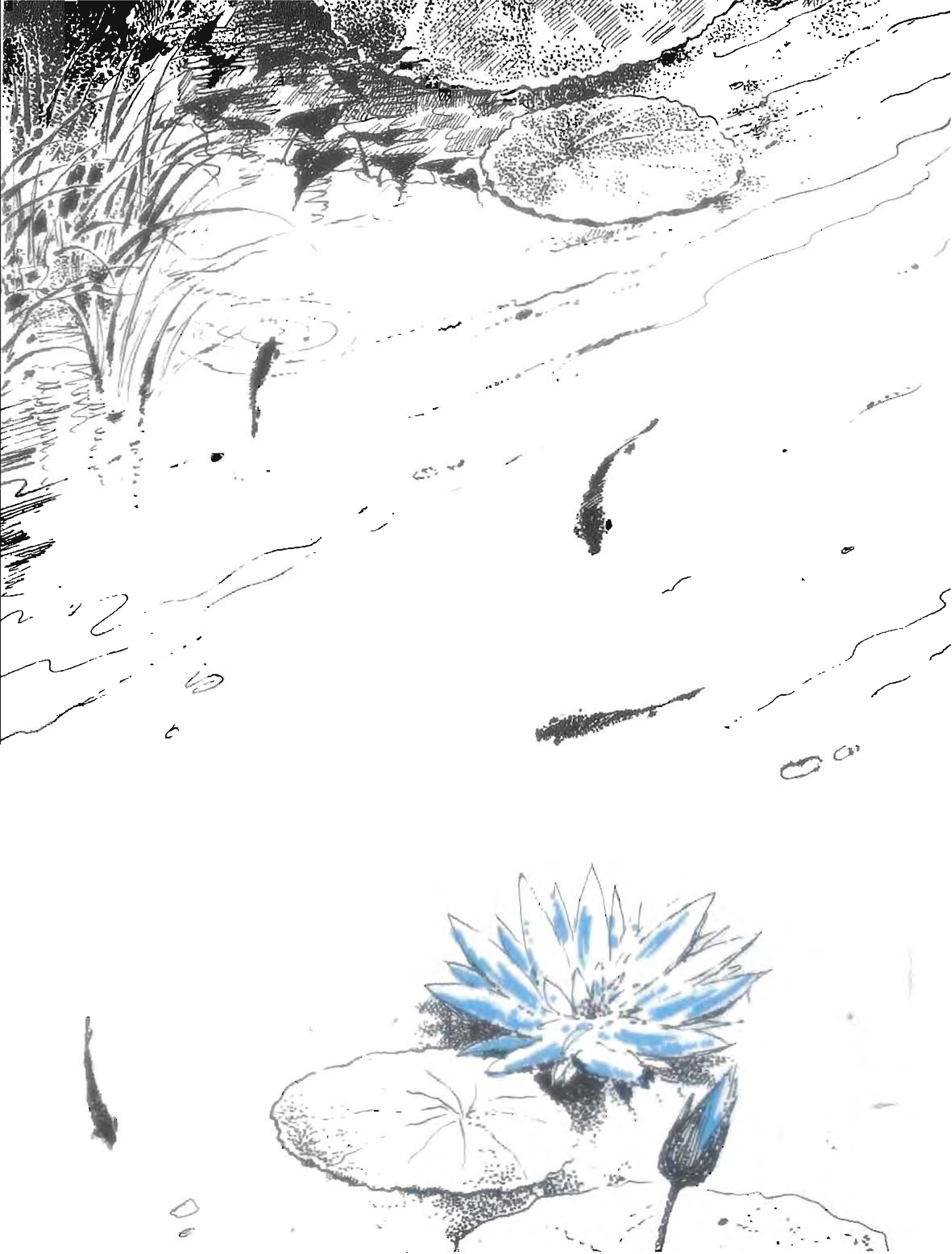
NATIONAL BOOK TRUST, INDIA



WATER SUSTAINS LIFE

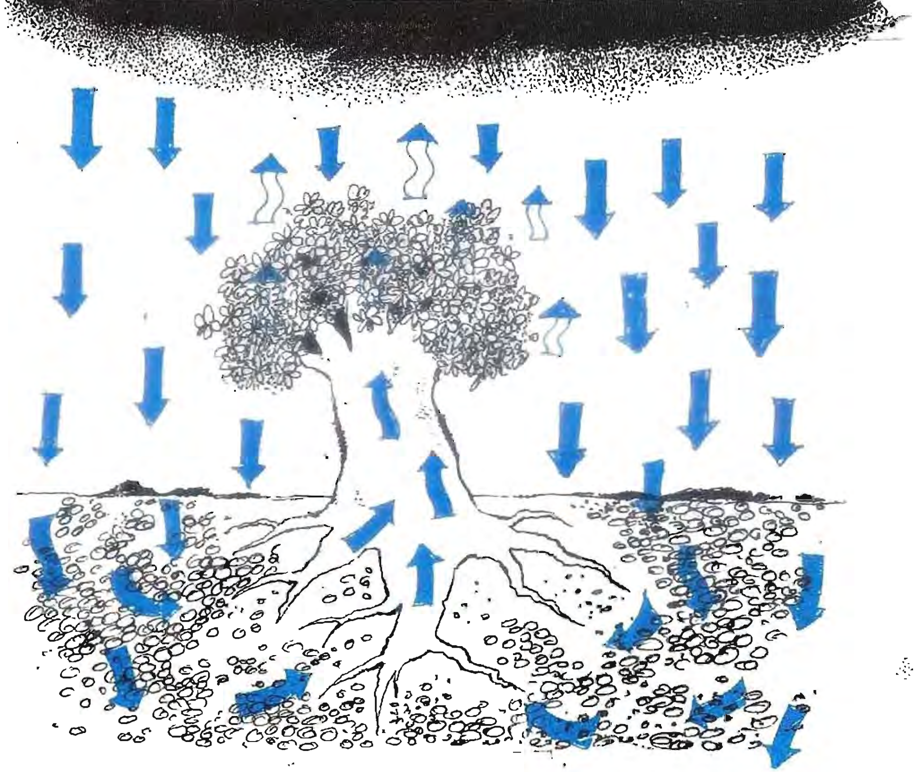
Everything that is essential for life is available in great abundance on the earth. Living creatures need air in order to breathe and air is plentiful. They must drink water and numerous sources of drinkable water—streams, lakes, springs, ponds—exist They must eat food. Food comes from plants, and plants are abundant over large areas of land. (Though some creatures do not eat plants, they live off other creatures which eat plants.) This easy availability of air, water and plants has brought about the proliferation of life that we see around us. Besides billions of humans, the

world is full of innumerable microbes, insects, birds and animals.

The three main necessities of life, air, water and plants, are indeed found in abundance on the earth—in abundant, but not in infinite quantity. Thus, animal populations too have been large, but not infinite, for they have been limited by the availability of plants which, in turn, have been limited by the availability of land and water.

Water and air are inorganic substances, and as such can exist forever. But plants are different. They are organic, and alive too. They grow. For this, they take carbon from atmospheric carbon dioxide, hydrogen from water, energy from sunlight, and become fatter, and bigger with time. While growing, they breathe. Their leaves breathe out a lot of water as vapour into the air. Birds and animals also breathe out water as vapour, but plants breathe out much more, for every leaf exhales water vapour. This is the water that is earlier sucked up from the soil by the roots of the plant and then delivered to the stem, from where it passed on to the leaves.

Therefore without water, there can be no plants, and without plants there can be no food and hence no life. We thus see that water is essential not only for supporting life on the earth but also for its very existence. Bodies of plants and animals are full of water. About seventy per cent of the weight of the human body is water. Blood is largely water. There is water inside and outside each cell. About ninety per cent of the weight of each living cell is water. Water is, therefore, needed in rather large quantities. Plants are enormous consumers of water. It is astonishing that our daily food (rice, wheat, dal, sugar, vegetables, etc.) comes from plants which have used up several thousand litres of water which



TRANSPIRATION

they have taken from the soil. In contrast, our daily intake of water (in the form of water, tea, coffee, milk, juice, soup, etc.) is only about a couple of litres. Our food therefore comes at an expense of about a thousand times as much water as we need to drink directly. In many regions of the earth, there is no problem about the availability of this much water. Where there is substantial and frequent rainfall, there is usually enough water in the soil and we see a luxuriant growth of plants, and trees, and large numbers of animals and other creatures which feed on them directly or indirectly. But in certain regions such as deserts, rainfall is scanty, and there is little mois-

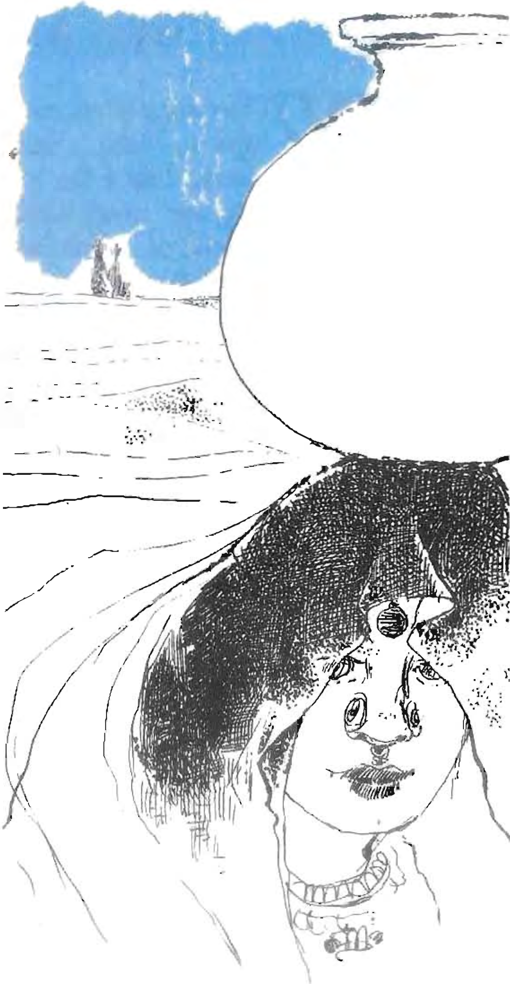
ture in the soil. Here plants are scarce, and so are living creatures.

Occasionally, rainfall eludes even those areas which usually have sufficient rain. When this happens, the soil becomes dry, plants wither and there is a shortage of food and drinking water. Trees with their long roots which penetrate deep into the soil can tap the underground water around them and survive longer but smaller plants, birds and animals begin to perish even when the scarcity is moderate. Human beings have learnt to cope with such scarcities somewhat better, having discovered that they can draw on a secret source of water. They have found that water is available almost everywhere on the land but that it is sometimes hidden underground and can be reached by digging a pit or a hole in the ground. Only human beings have learnt to make holes in the ground to get at this hidden water. Animals and birds have to locate a visible source of water and then reside somewhere close by. In the distant past, human beings too had to do this. They needed to live on the banks of rivers and lakes. But, over the years, they have acquired the expertise and technology to tap water from under the ground and to divert the water of streams to far off places. This has widened the area where human settlements can be located. But the

basic fact remains that there must be some source of water, natural or artificial, and that without water no habitation is possible.

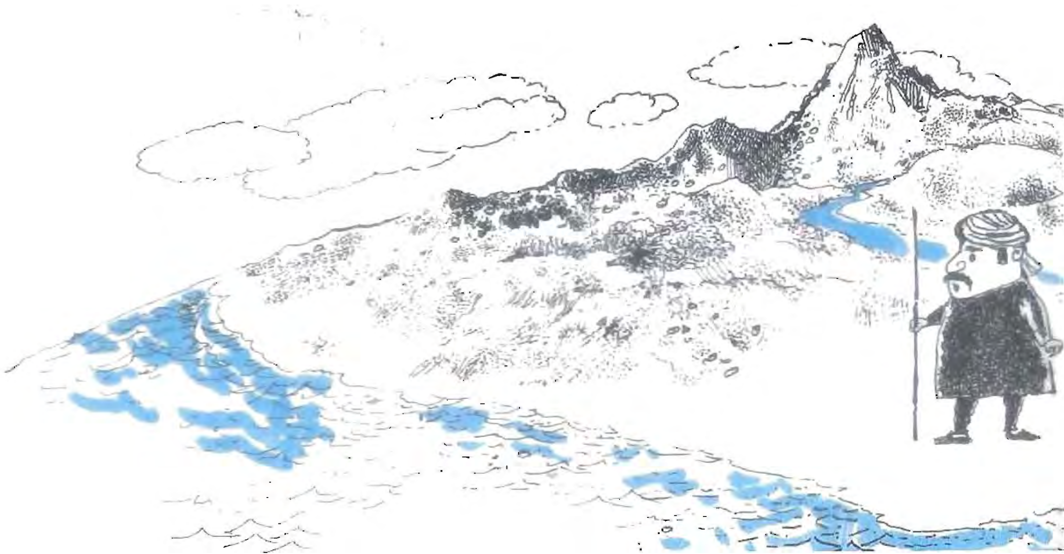
In addition to quenching thirst, we need water for washing and cleaning. Our daily consumption for these purposes can be anything from a few litres to hundreds of litres, depending upon the supply and on the means at our disposal to tap this supply. After domestic use, the water becomes a little dirty and we throw it away since there is usually plenty of clean water available. We often have enough clean water to wade in, to swim in and for sailing.

Water appeals to the aesthetic sense of human beings; it has inspired poetry and spurred romance. Many communities worship water—seeking its bounties and an escape from its wrath. Everything in human life is, in some way or the other, tied to water.



ALL AROUND US

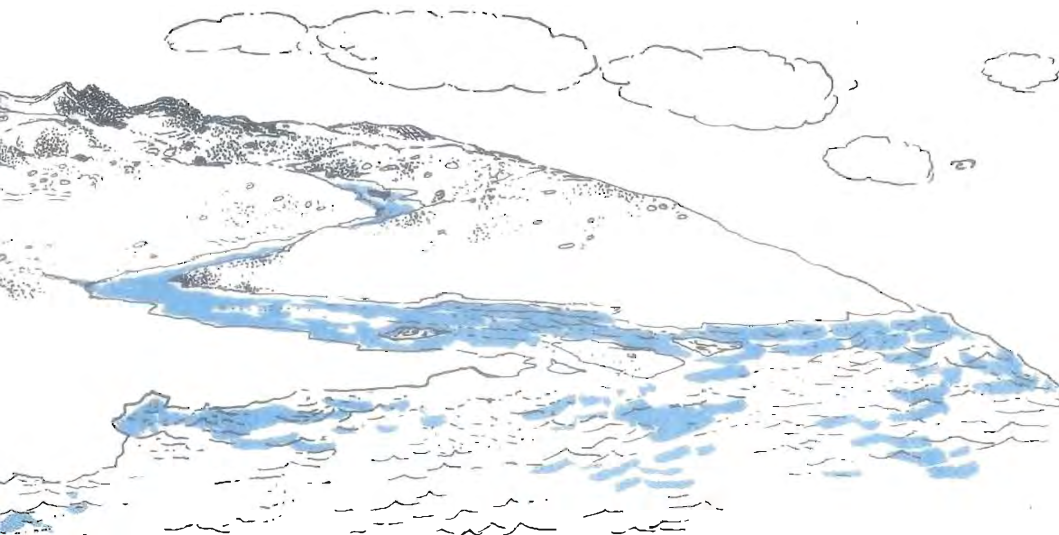
When seen from outer space, the earth looks like a big ball of water. Oceans cover about seventy per cent of its surface. The polar regions and mountain tops are covered with ice, i.e., solid water. The continents are dotted with numerous lakes, ponds, springs, marshes and streams. The entire globe is engulfed in a blanket of air which has a substantial amount of water vapour in it. If all of this vapour were condensed it would cover the globe with fresh water to a depth of a few centimetres. In fact, this is a natural process and occurs, off and on, in one place or another all the time. At any given moment, a good part of the globe



is covered by clouds, some of them yielding rain and some snow. The rain and snow nourish streams, lakes, springs, marshes and glaciers. Let us take a closer look at these bodies of water, starting with the biggest, the oceans.

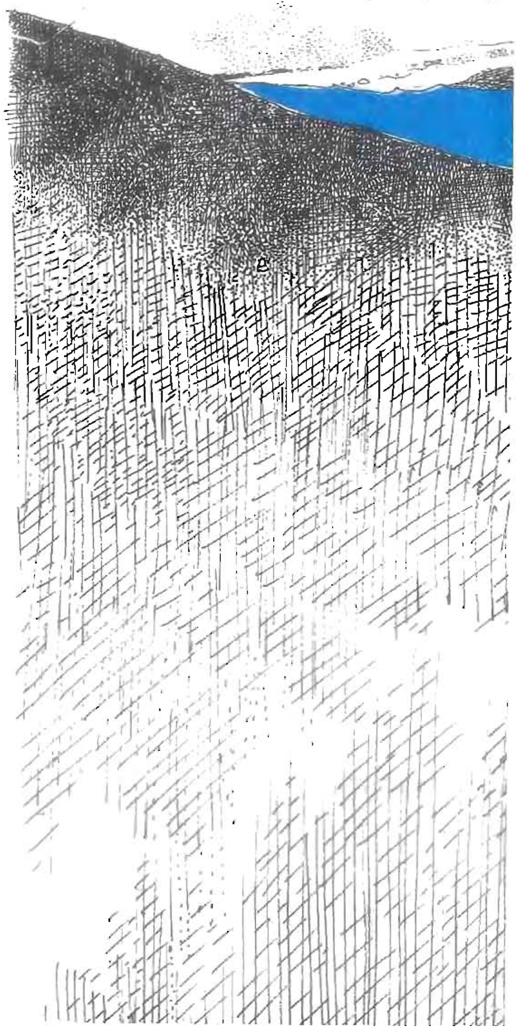
OCEANS

From the shore, the sea appears to be a vast, endless sheet of water. It is indeed vast, but not endless. Nor is it bottomless. Near the coast, the water is shallow—we can wade in it. If we move away from the coast, the water becomes deep, but usually very gradually. This shallow part of the sea, adjacent to the coast, is called "the Continental Shelf". The shelf is merely an extension of the coast under the sea. Beyond the shelf, the water begins to deepen very fast, and within a few kilometres from the edge of the shelf, the water is about four kilometres deep, and stays that deep till we reach the

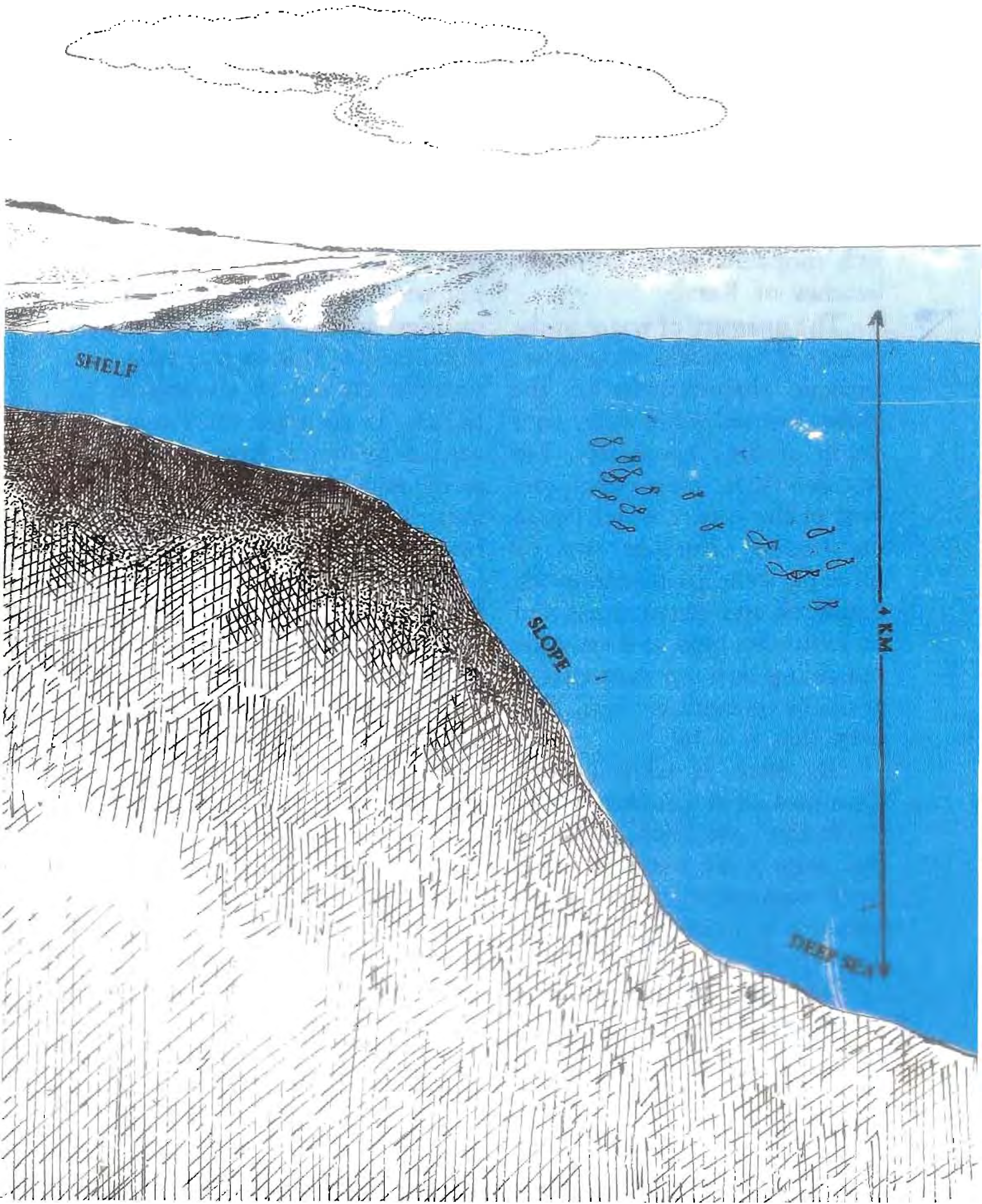


shores of another continent. In between, we may encounter spots where the water is deeper, perhaps seven to eight kilometres. These are called "trenches". In some parts, we may come across hills that rise several kilometres above the sea floor. Some may even rise above the water. We call them "islands". But, by and large, the seabed is very flat and lies at a depth of about four kilometres.

The shelf, i.e., the shallow sea adjoining the coast, is usually ten to twenty kilometres wide, and is rich in marine life and minerals. India's western shelf, adjoining the Bombay-Goa coast, is unusually wide (about 200 kilometres) and is



CONTINENTAL SHELF →


SHELF
SLOPE
4 KM
DEEP SEA

bountiful in every respect. We get a good catch of fish and prawns all along the coast. We are drawing oil from this shelf, near Bombay. Without effort we can just pick up thorium-rich monazite sands from the beaches of Kerala.

The quantity of water in the oceans of the world is immense. Imagine three-fourths of the globe covered with water to a depth of four kilometres. No wonder that ninety-five per cent of the earth's water lies in the oceans. Another two or three per cent lies frozen in the Antarctic and Arctic areas and on mountain tops. It is only the remaining two per cent that is available on ordinary land. But even that is a lot.

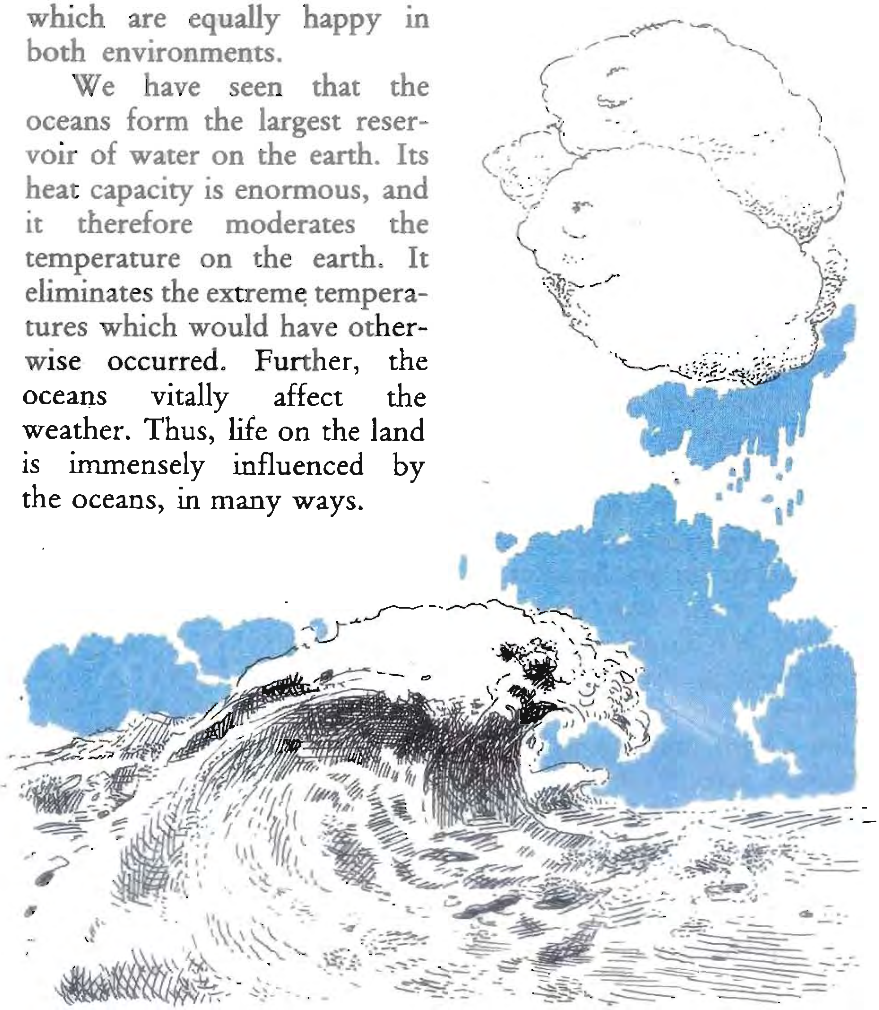
Sea water is saline (salty). One litre of it contains about thirty-five grammes of salts. But, why is sea water so saline when rainwater, which replenishes it is usually as clean as distilled water?

Sea water is salty because after rain falls on the ground, small quantities of salts from the soil and rocks dissolve in it. This slightly saline water flows into streams. The salinity of stream water is usually so low that we cannot detect it by taste but we can measure it in laboratories and by using special instruments. This slightly saline water is carried by streams to the sea. In contrast, the vapour carried by winds from the sea to the land, where it condenses into rain, is almost completely free of salt. The salt movement is therefore a one-way traffic—from the land to the sea. This one-way traffic has been going on for a very, very, long time—for at least two billion years and has made sea water saline, very, very slowly but surely. The process is still continuing.

There is a great abundance of life forms in the sea. But certain plants, animals, birds and other organisms accustomed to living on land and in fresh water find it difficult to

survive in the salinity of the sea. There are some, however, which are equally happy in both environments.

We have seen that the oceans form the largest reservoir of water on the earth. Its heat capacity is enormous, and it therefore moderates the temperature on the earth. It eliminates the extreme temperatures which would have otherwise occurred. Further, the oceans vitally affect the weather. Thus, life on the land is immensely influenced by the oceans, in many ways.



RAINFALL

We often see drops of water falling from the sky. When accompanied by lightning and thunder, we witness the enactment of an impressive drama of nature. Our ancestors observed this drama keenly for thousands of years and modern scientists have also studied it closely. As a result, we now understand its basic features.

Because of the sun's heat, water evaporates from the sea. It also evaporates from the soil, plants and water bodies like lakes and streams on land. This vapour enters the air above, and is carried by the air. Apart from moving from one place to another, the air also moves up and down in the atmosphere. When it moves upwards, it goes from a high pressure to a low pressure area. It therefore expands, and in the process does some work, when it pushes the surrounding air away. It uses its own heat energy to do this work and thus gets cooled. If

the cooling is enough, the vapour condenses around tiny dust particles which the air always carries with it. These tiny droplets of water stay afloat in the air, and are seen in the form of a "cloud". Millions of these droplets need to join together to form just one small drop of a millimetre or so in size. When this happens, the drop becomes too heavy to stay afloat, and falls to the ground as a raindrop. If the air gets too cool, the water droplets may freeze and become ice. When many of these ice specks join they make a snowflake, and when they drop we get a snowfall. We thus see that several processes have to take place for rainfall to occur. And they do occur often enough, for that is how we get rain. But the uncertainties in each step and their sequence are so great that they often defy our attempts to forecast rainfall correctly and well in advance. We are not able to tell with any certainty when it will rain at a given place or when it will stop. Nor have we invented any definite method which can bring rain or stop it at will. This failure is the result of the intricacies of the phenomenon, not because of any

deep unsolvable mysteries in it. We are aware of the intricacies but have not yet got a grip on them.

Sometimes we are puzzled by questions which have simple answers. For example, we may ask how we get large amounts of rainfall, 20 centimetres or more in a day, when the overhead air contains only a small amount of water vapour and, furthermore, when only a fraction of this vapour condenses into rain. The answer is simple. Air moves. A large amount of air may pass overhead, shedding rain as it goes along. Air thus acts as a conveyor belt for water, bringing it from afar and dropping it overhead.

There is a lot of folklore about rain. Much of it is based on observation, and has some truth to it. But, the language and expressions used are often loose and misleading. It is commonly known that rainfall is more plentiful in the hills than in the adjoining lowlands. Folk

belief has it that clouds strike the hills to give them heavy rain. In fact, when a barrier like a hill is in the path of moving, humid air, it forces the air to rise and thus to get cool. The cooling results in condensation and rainfall. There is no need for a collision. We sometimes see clouds enter houses in the hills, and make them damp. There are no collisions.

It has also been observed that it rains a lot over forests. Thus it is commonly said that forests attract rain. The fact is that trees and plants thrive wherever rainfall is abundant. The forests of our Western Ghats exist because of ample rainfall. Here, the presence of ghats (hills) rather than of forests facilitates rainfall. But the belief that forests attract rain is not entirely wrong. Imagine a very large forest of hundreds of kilometres across in each direction. The trees in this forest, breathe out a lot of moisture into the air. This makes the air above the forest more humid, and therefore more amenable to rainfall. There is a strong possibility that this extra-humid air will yield rain somewhere over the forest itself before it moves elsewhere. Thus over a very large forest the possibility of rainfall is reinforced.

We sometimes hear the expression "cloud burst". This is simply the occurrence of a large amount of rainfall in a short time. It occurs under certain atmospheric conditions which, though infrequent, do arise once in a while. Nothing bursts—only the intensity of rainfall is high. Such high-intensity rains, lasting for even a few hours, can cause severe floods.

We also have cyclones which can cause great devastation. Cyclones are big whirlwinds moving over the sea. When they come towards the land, still whirling, they cause a great deal of havoc to the coast-

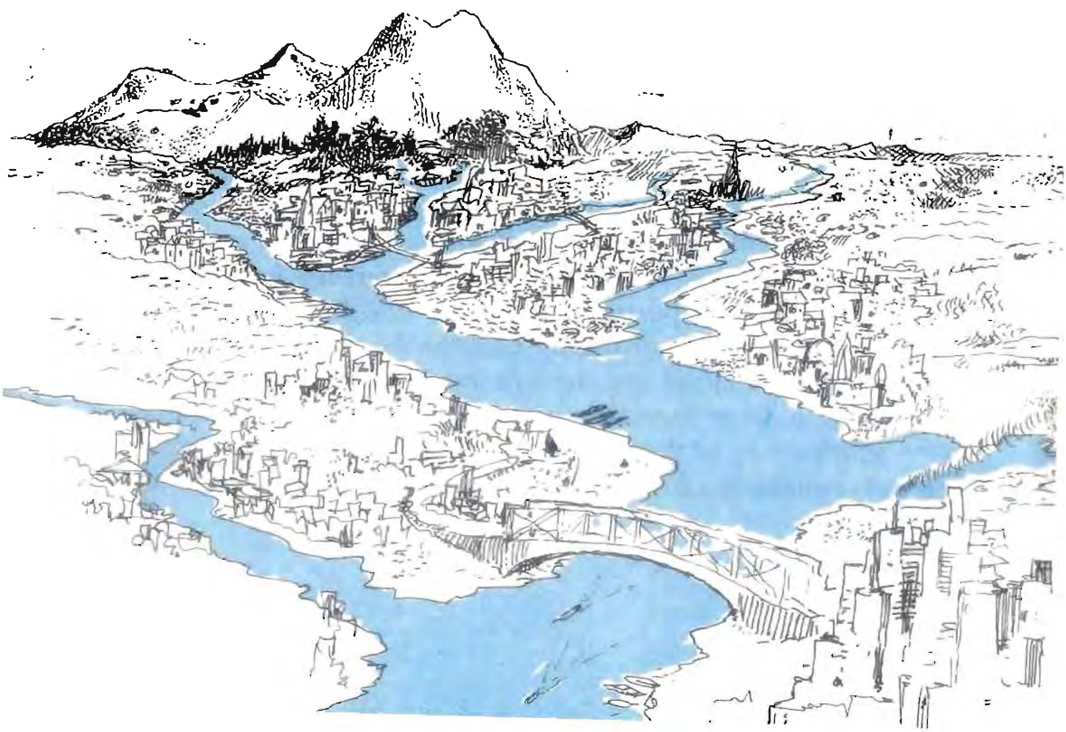
al areas over which they pass. They bring a lot of rain along with strong winds which uproot trees and blow away rooftops. More devastating still is the huge wave of sea water (tidal wave) brought by gales. The fury of the cyclone is however spent within about a hundred kilometres from the coast. Cyclones visit our east coast oftener than our west coast. Though over a limited region, their devastation is usually very severe.

Another natural phenomenon which causes destruction over limited areas is hail. Hailstones are balls of ice, ranging in size from a pea to an orange. When you cut or break a hailstone, you will notice that it consists of two layers, one clear, the other hazy. Scientists believe that the clear portion is formed from water droplets collected from a cloud and the hazy portion from snowflakes from another part of the cloud. Further, hailstones can increase in size only when there is a very strong upward draught of air. In other words, hail is formed only in a severe thunderstorm. Since hailstones strike the land, crops and living creatures with the force of falling stones, causing great devastation, scientists are trying to find means to suppress hail formation.

The vital importance of rain has led to various attempts by scientists to control rainfall. One of the experiments that is commonly conducted is called "seeding". A large number of small particles of common salt, silver iodide, solid carbon dioxide, etc. are introduced into clouds, with a view to induce the water vapour to condense around these particles and come down as rain. The success of such experiments has not been proved conclusively, but the benefits that we in India would derive from being able to control and change the distribution of rainfall make these experiments very important for us.

STREAMS

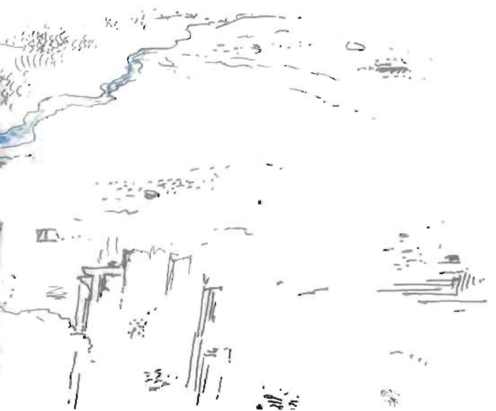
When raindrops fall on the ground, all of them may be soaked into the soil. But if the rain is persistent and intense, the soil is unable to absorb all of them, and the water begins to collect over the ground and then flow to a lower level. Flowing water creates natural channels in which it can flow more easily. At a lower level, small channels join, and form a bigger channel, and these bigger channels join to form still bigger channels. The largest channel runs along the lowermost areas. This process of water flowing from a higher to a lower level and ultimately finding its way to the sea has been going on for millions of years. This has created streams, and small streams leading to big streams, which in turn lead to rivers, some of which may join



to form a mighty river. The system of streams and rivers in a given region is sometimes called the "drainage system", because it drains the water from the region. The actual pattern of the drainage system and characteristics of individual streams depend on several factors, such as the nature and topography of the rocks and soil and the characteristics of the rainfall in the region.

Most streams receive water from two sources—the overland flow and the underground flow. The overland flow is the flow of excess water from the land via small and big streams. This flow is visible to us. But many streams continue to run for a long time after the rain and the overland flow have stopped. This happens because some of the water which soaks into the soil and goes deep underground, continues to flow underground and seeps into the stream channel. Since streams, as a rule, run along low, level areas, they can easily receive this underground flow. That is how many of them have some water even during the dry season.

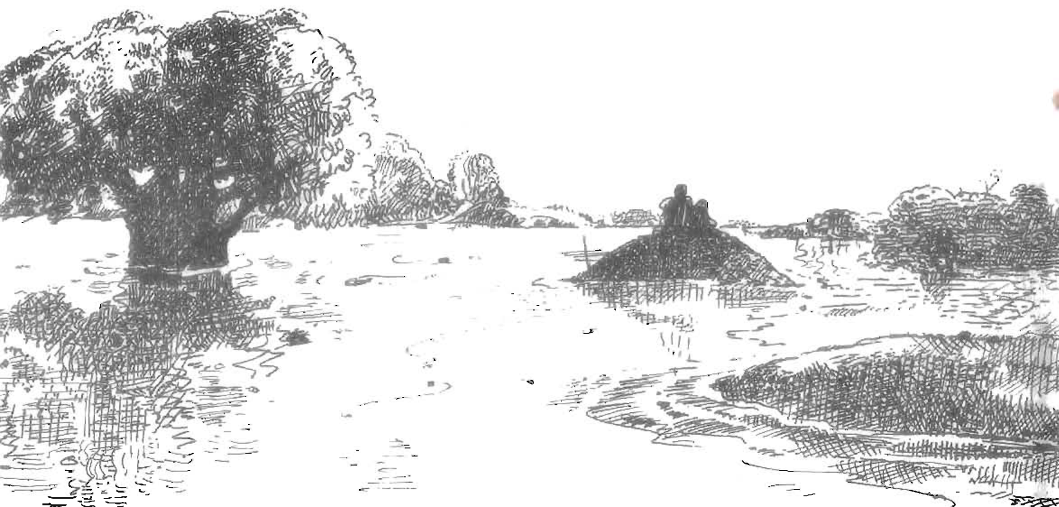
Some streams originate from glaciers in the high mountains. They get additional water when the glacier melts during summer. Thus, most of our rivers that originate in the Himalaya, run throughout the year. Even these Himalayan rivers, however, carry the bulk of their water during the rainy season. The water from glaciers, though not very large, is very useful. Many canals in the Indo-Gangetic plain are fed by this water.



FLOODS

Sometimes it rains heavily and the rain lasts for hours and sometimes even days. This produces an overland flow which is beyond the carrying capacity of streams. The water then spills out of the banks and floods the neighbouring areas. These floods are a natural phenomenon. We should stay out of their way. But, due to the increase in population, people have begun living very close to streams. In order to ward off floods, they build high bunds along the banks of rivers and streams so that their waters are contained within the banks. This might solve the local problem but sends a bigger flow of water downstream and can cause greater floods there. There are other methods of flood control which do not shift the damage from one area to another. Flood water can be held in reservoirs and released gradually and systematically. Reservoirs are built by putting dams across streams and rivers.

In India, floods seem to have become more frequent in recent times. The cause is "de-

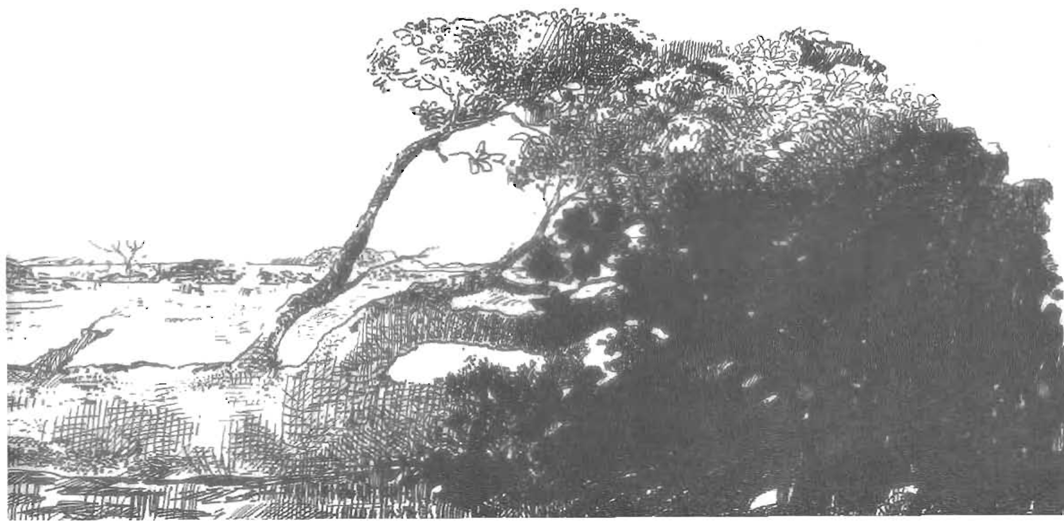


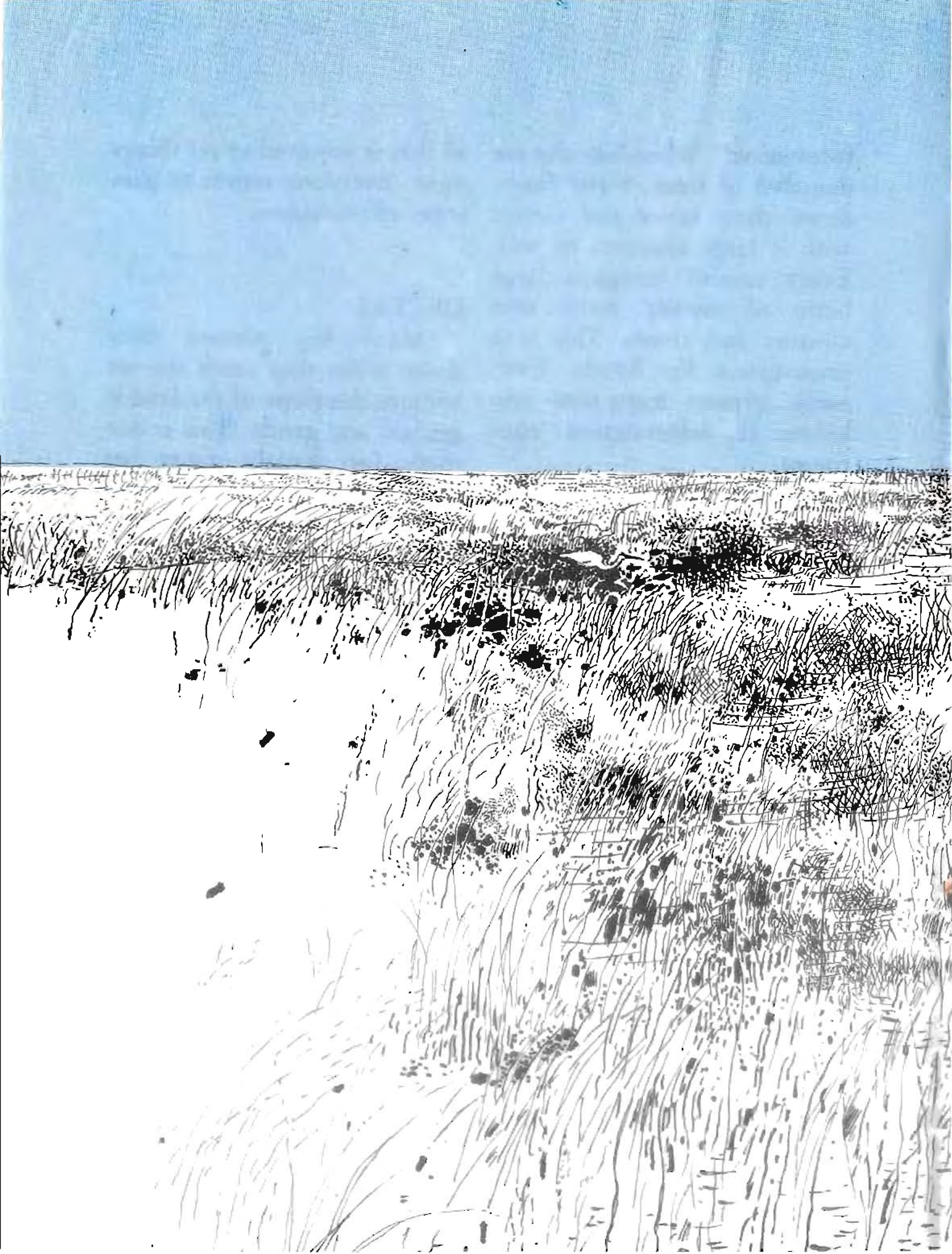
forestation". When hillsides are denuded of trees, water flows down them faster and carries with it large amounts of soil. Every rainfall brings a large body of muddy water into streams and rivers. This is a prescription for floods. Even meek streams may turn into killers if deforestation continues.

Afforestation of deforested lands is therefore essential. Afforestation is merely a rectification, a correction, of a mistake. It is in no one's interest to keep the land barren. Effort is all that is required to set things right. Everyone stands to gain from afforestation.

DELTAS

Many big streams slow down when they reach the sea because the slope of the land is gradual and gentle. This is due to the fact that the stream has been dumping mud there. In such regions the stream may split into many small channels which lead to the sea. This area is called a delta. It is usually very fertile.

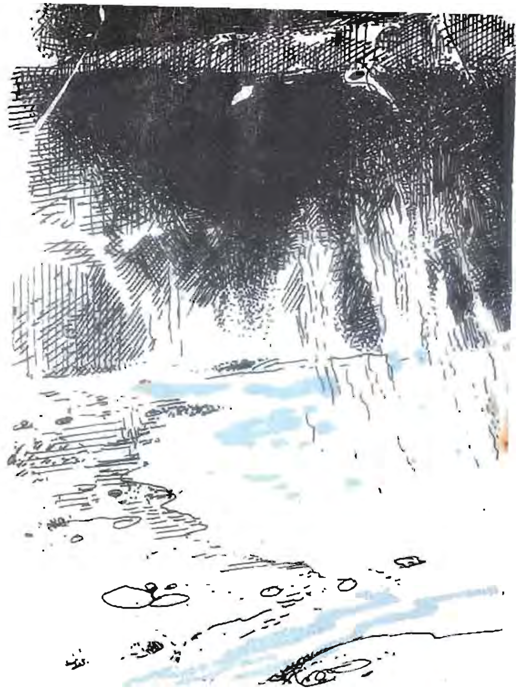




PONDS, LAKES AND MARSHES

When water collects in a pit or a depression, it is called a pond. When the pond is large and deep, it is called a lake. A large shallow sheet of water is a marsh. Near the coast, sea water inundates low-level areas during high tide. This creates a salt marsh which may drain away at low tide.

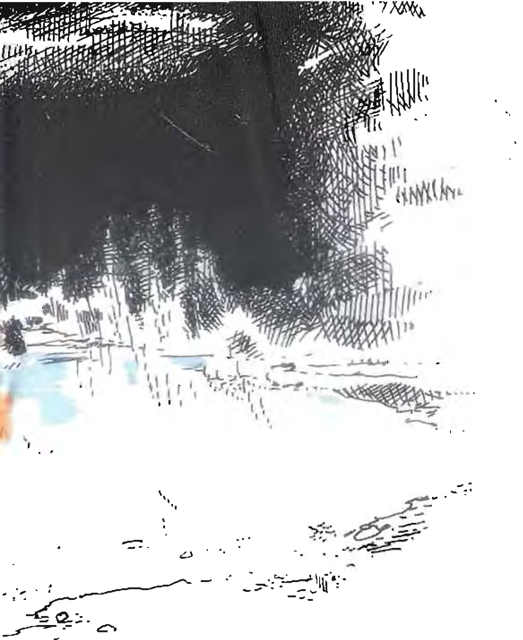
Lakes can be very big. Some lakes are almost the size of a small sea. Lake Superior in North America and Lake Victoria in Africa are very large lakes. But in our country we have comparatively small lakes, mostly in the hills. In Kashmir, for example, we have the Dal and Wular lakes. Our artificial lakes are more numerous and bigger than our natural ones. They are made by impounding the waters of our rivers and streams by putting dams across them—the Bhakra, Hirakud, Tungabhadra, to mention a few.



SPRINGS

If we see water oozing or gushing from the ground, we call it a spring. We often come across springs on the side of a hill. They arise when the groundwater of the hill finds outlets in the hillside. These springs may dry up during a prolonged dry period.

We sometimes also see water gushing out of a rock in the plains at the foothills. The

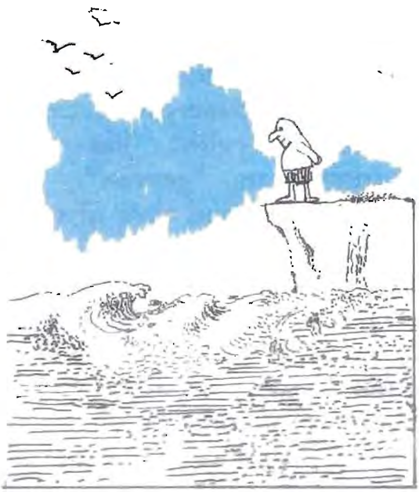


water may be warm, or even so hot that it emerges as steam. These are called "hot water springs" or "geysers". The temperature and flow of water in these springs does not change a great deal with time because it is probably fed by a large reservoir underneath. The source of heat is some deep-lying rock. Because of some peculiar geological conditions, rainwater from the hill sinks deep (perhaps several kilometres), gets heated, and is forced up and escapes at the outlet. In India we do not have any really famous springs, warm or cold, but we do have some unspectacular ones.

GLACIERS

The Arctic and Antarctic are very cold. Snow falling there has very little chance of melting. There are large stretches of snow, compacted into ice, called "glaciers" covering land and sea. Similarly, on high mountains there are thick sheets of ice covering the slopes and filling the valleys. The lower ends of mountain glaciers lie in areas where the melting of some ice takes place, and the resultant ice cold water flows down to the plains. Many Indian rivers originate from glaciers in the high Himalaya. Besides the rivers of the Punjab, some of the great rivers that flow throughout the year are the Yamuna, the Ganga, the

Sarda, the Ghaghara, the Gandak, the Kosi, and the Brahmaputra. During summer, they bring substantial amounts of melted ice to the plains. However, if we compare the yearly snowfall in the mountains and yearly melting of ice, we find that the two are approximately equal. Therefore, the size of glaciers remains more or less constant. But, if the world's weather becomes warm and stays warm for a long time, glaciers begin to shrink from their lower ends upwards. If, however, the weather is cold for long periods, the glaciers become bigger, and more and more water gets locked as ice. The earth has experienced long cycles of cold and warm weather in the past, and with it the expansion and shrinkage of glaciers. But this happens very slowly. It takes thousands of years to see any marked change.



Normally, water that has evaporated from the sea and fallen as rain or snow is returned to the sea by streams. But if more and more water begins to get locked as ice in glaciers during cold periods, the sea-level falls. The reverse occurs during long warm periods on the earth. More water is released from glaciers and the sea-level rises. There is evidence from the distant past of the sea-level falling and rising.

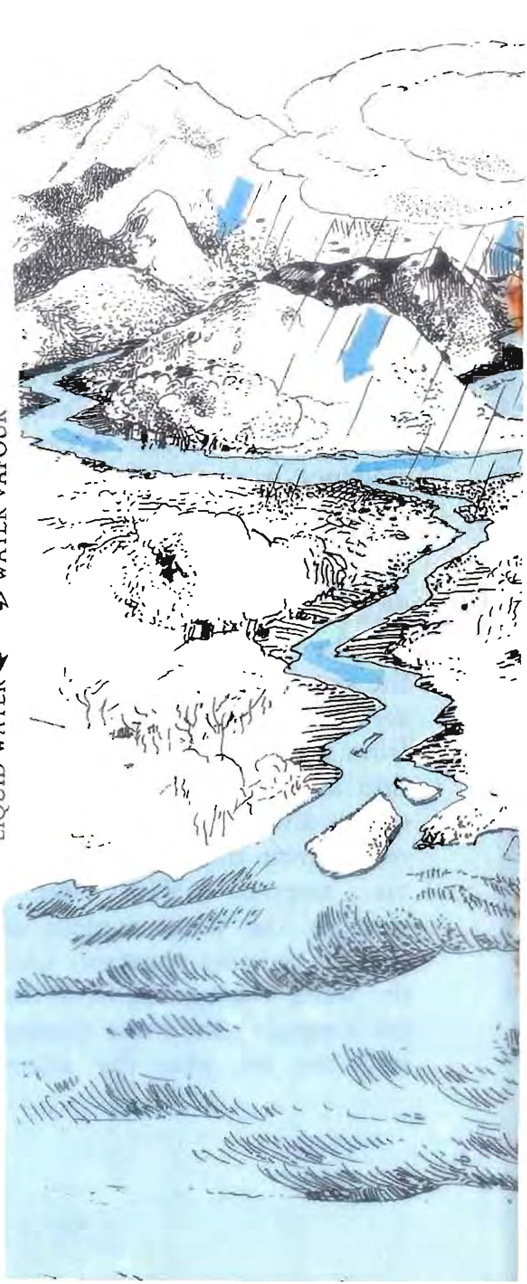
WATER CYCLE

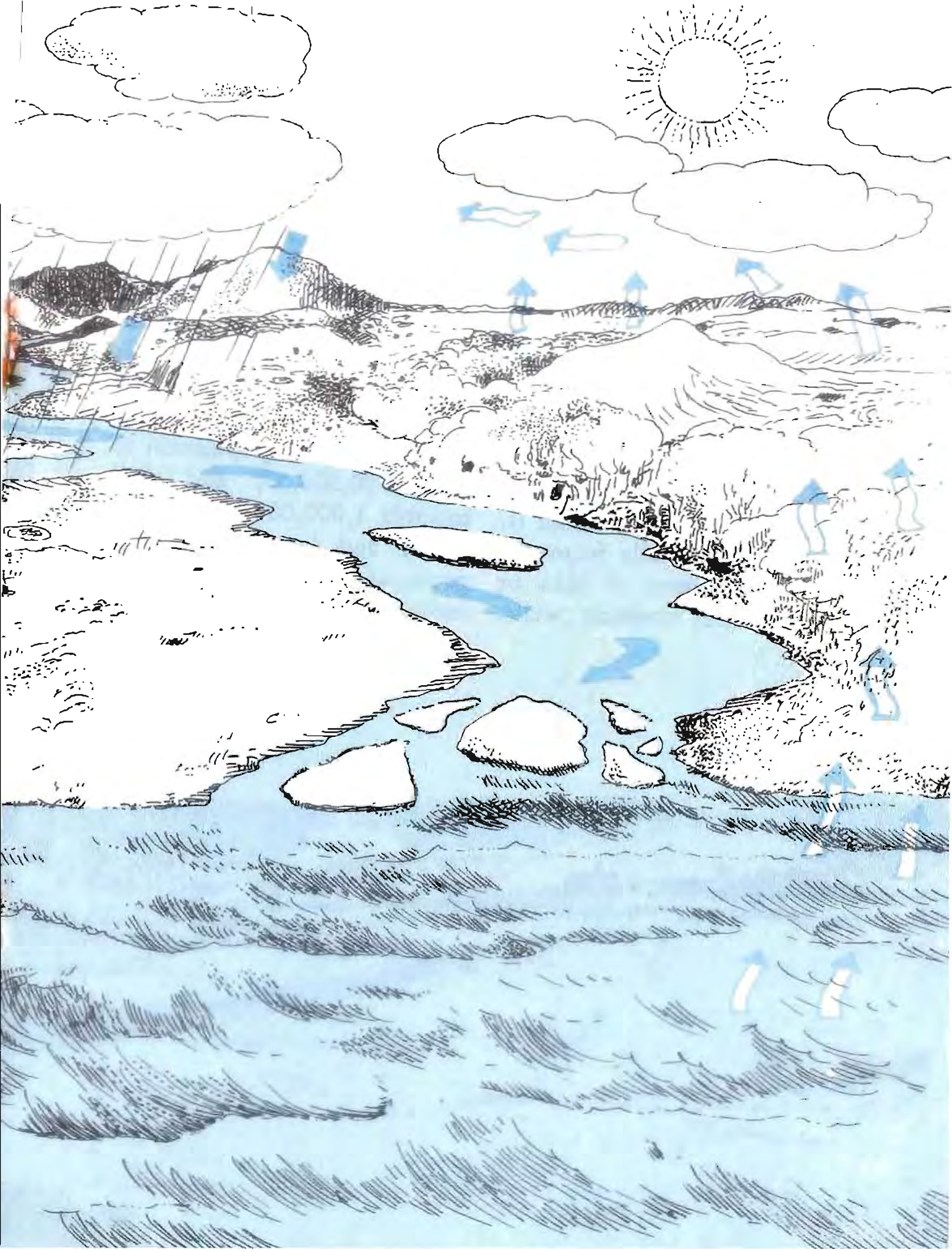
The water cycle is ruled by the sun. Its major components are (i) the evaporation of water from the sea, (ii) its precipitation as rain or snow over the oceans and the land, and (iii) its return from the land to the sea via streams. With minor changes, the water content of the sea remains constant, i.e., the water evaporating from the sea is equal to the water raining into the sea plus the water brought by streams to the sea.

In this immense cycle, there are sub-cycles. For example, a part of the rainwater falling on the land soaks into the soil. Some of the soaked water is breathed out by plants into the air, and is re-precipitated as rain or snow. The remaining portion of the soaked water gradually percolates through the soil and meets an underground body of water. This underground water moves down the natural gradient of the land till it meets a stream, merges with it, and flows to the sea. Streams thus carry water that flows into them from over the land as well as from under the ground. As mentioned earlier, similarly, rainwater is partly derived from vapour that comes from the sea and partly from that which evaporates from the land.

We have seen that water exists on the earth in three forms, i.e., vapour (in air), liquid (in oceans, lakes and

streams), solid (in glaciers). It also changes from one form to another. Liquid water evaporates into gaseous vapour; vapour condenses to liquid rainwater; water freezes into solid ice, and ice melts into liquid water. But, at any moment the quantity of any of these forms of water is more or less constant. Small variations occur in response to changes in climate but it takes thousands of years for any real difference to occur in global climate. A cold or warm spell may last millions of years, holding water in each phase constant over long periods. On the earth, the largest amount of water (about ninety-eight per cent) exists as liquid, a small amount (about two per cent) as ice, and a very, very small amount as vapour in the air. Although, at any moment, this vapour is a very small fraction of the total, it is this which becomes rain and sustains life on land.





OUR SHARE

Now, let us look at the picture in India. Do we have enough water to irrigate our farms, for it is irrigation which requires very large quantities of water.

RAINFALL

There is only one perennial source of fresh water, that is, the water that falls from the sky, in the form of rain or snow. Rivers, streams, wells, lakes and springs all derive their existence from it. In its absence they would all dry up. Rainfall is our most important resource, and we are fortunate to have it in plenty. Its abundance has led to a luxuriant growth of plants and enabled our population to reach 700,000,000 and head towards 1,000,000,000.

By and large we have a generous amount of rainfall in India. But, in some areas it is

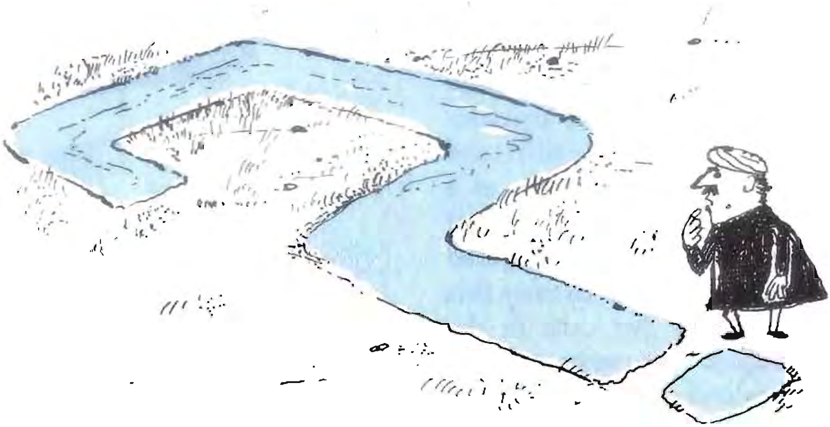
very scanty. Much of it occurs in the months of June, July, August and September. These four months form a distinct season, the "rainy season". But even during this season it does not rain equally all over the country. We get heavy downpours over Assam, the Lower Himalaya and the Western Ghats, but there is hardly any rain over the Thar desert in Rajasthan, rather poor rains over north Gujarat, west Haryana, Marathwada, Telengana and parts of Karnataka. There is a further problem. Our rainfall is erratic. It often comes in spurts, and causes floods. Sometimes the gap between successive bouts of rain is very long, and the soil dries up. Then we have a drought. Nevertheless on the whole, the behaviour of our rainfall is quite good, and the country abounds with life. But not all of this life and activity has been brought about by rainfall; the human hand has also played its part.

SOIL MOISTURE

As we have already observed, when rain falls on the ground, some of it soaks into the soil, making the top soil wet and the excess flows into streams. The top soil, however, can hold only a fraction of the water that falls on it, the rest gradually percolates deep down. It is the water held by the top soil that is sucked up by plant roots and exhaled by their leaves into the air. Thus, for plants to thrive, the top soil must be adequately moist during the period of their growth. If the top soil dries up, plants wither. So it is vital that our crops have a sufficiently moist top soil. Trees fare much better. Their roots penetrate deep down into the soil and spread over a large area. Consequently, they are able to draw their requirements of water more easily, and do not suffer greatly during short periods of drought.

HARNESSING RIVER WATER

When our population was small, we could manage with crops we grew in naturally rain-watered soil. But with the steep increase in population, it became necessary to grow crops even when the rains failed or were scanty. It became necessary to water the soil artificially, i.e., to resort to irrigation, and harness our water resources by building canals, which carried river water to our farms, or by drawing up groundwater which would normally have seeped into streams and ulti-



mately found its way to the sea. We have also learnt to store flood waters behind large dams and release them later through a network of canals. Some of our canals carry a great deal of water and run long distances. The Indira Canal, for example, takes water from the Punjab rivers to the desert areas in Rajasthan.

Canals and wells enable us to grow two or three high-yielding annual crops. If, by mischance, any of our big canals stops functioning, millions may have to starve. The problem is acute. Our population increases by about 10,000,000 every year. Food must be grown for it, which means that more agricultural land must be irrigated. It is, therefore, necessary not only to keep existing irrigation facilities functioning but also to build new ones. We already have the world's largest irrigation network and it is getting bigger daily—but how much bigger can we make it?

The Punjab, Haryana, western Uttar Pradesh, parts of Tamil Nadu and Gujarat, and small areas of other states have

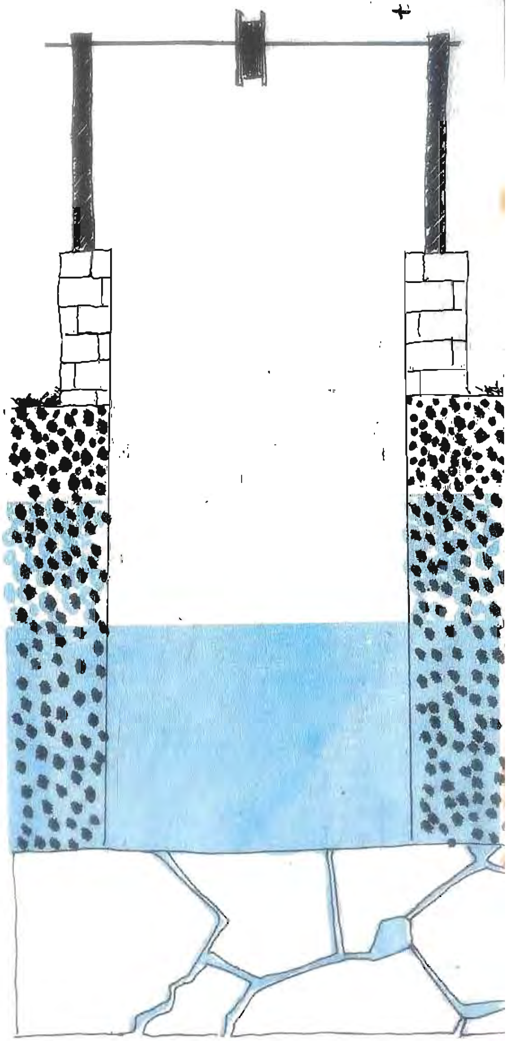
already been provided with irrigation facilities for more than fifty per cent of their farms with visible benefits. An adequate water supply has greatly improved agricultural production and resulted in all-round progress. For the country as a whole about thirty per cent of our agricultural land is irrigated and we are planning to raise this figure to fifty per cent in the next fifteen or twenty years. This means storing behind dams the waters of many rivers. Dams can be built to hold the waters of the Narmada, Tapi, Godavari, Krishna and several others. But the flood waters of many rivers flowing from the Himalaya and of several rivulets flowing from the Western Ghats into the Arabian Sea are difficult to dam inexpensively because of their steep slopes. Before embarking on irrigation projects we have to ensure that they are economically viable. Fortunately this is so in most cases.

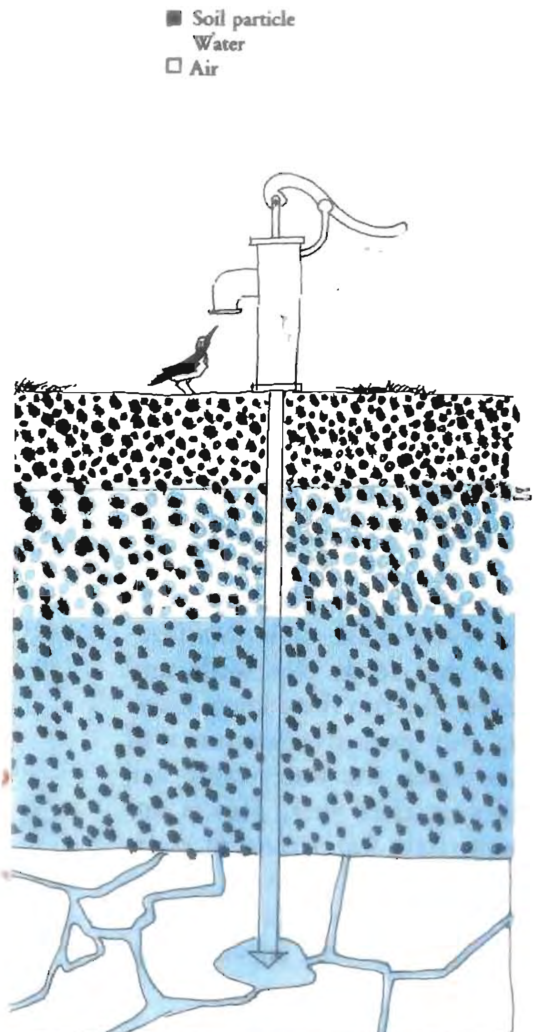
GROUNDWATER

Besides availing of river water stored in reservoirs and channelled through canals, we can also tap groundwater to irrigate our fields. This is easier to do and more convenient for there is a fairly large amount of water in the ground.

If we dig a pit, we first come across a thin layer of dry soil, then for several metres underneath somewhat wet soil. If we dig deeper, we find soil oozing with water and water begins to collect in the pit. This depth is the "spring level" or "water-table level". Below this, the pores of the soil are completely filled with water, and there is no space for air. If we continue digging, we eventually meet a hard compact rock with no open space and hence no water.

Though this is the general pattern, there are considerable variations in the depth and thickness of different strata of soil. At some places, in fact, in over half of India, the soil cover





is very thin and we meet rock at a depth of only a few metres or even less. This region is called the "hard rock area".

There can be, and usually is, some water even in hard rocks, particularly at shallow depths. Most rocks have cracks, fractures and fissures which get filled with water if water is available. Some rocks, like sandstone, are porous and water seeps into their pores. But the rock that is most susceptible to the action of water is limestone. Some limestone areas are warrens of caves and tunnels of all sizes and shapes, carved out by water flowing over them over the years. If enough water is available, the entire mesh can be filled with water. Only this type of rock has underground channels of flowing water or large cavities filled with it. If such cavernous (having caves) limestone is close to the sea, its underground network of streams discharge a large quantity of fresh water into the

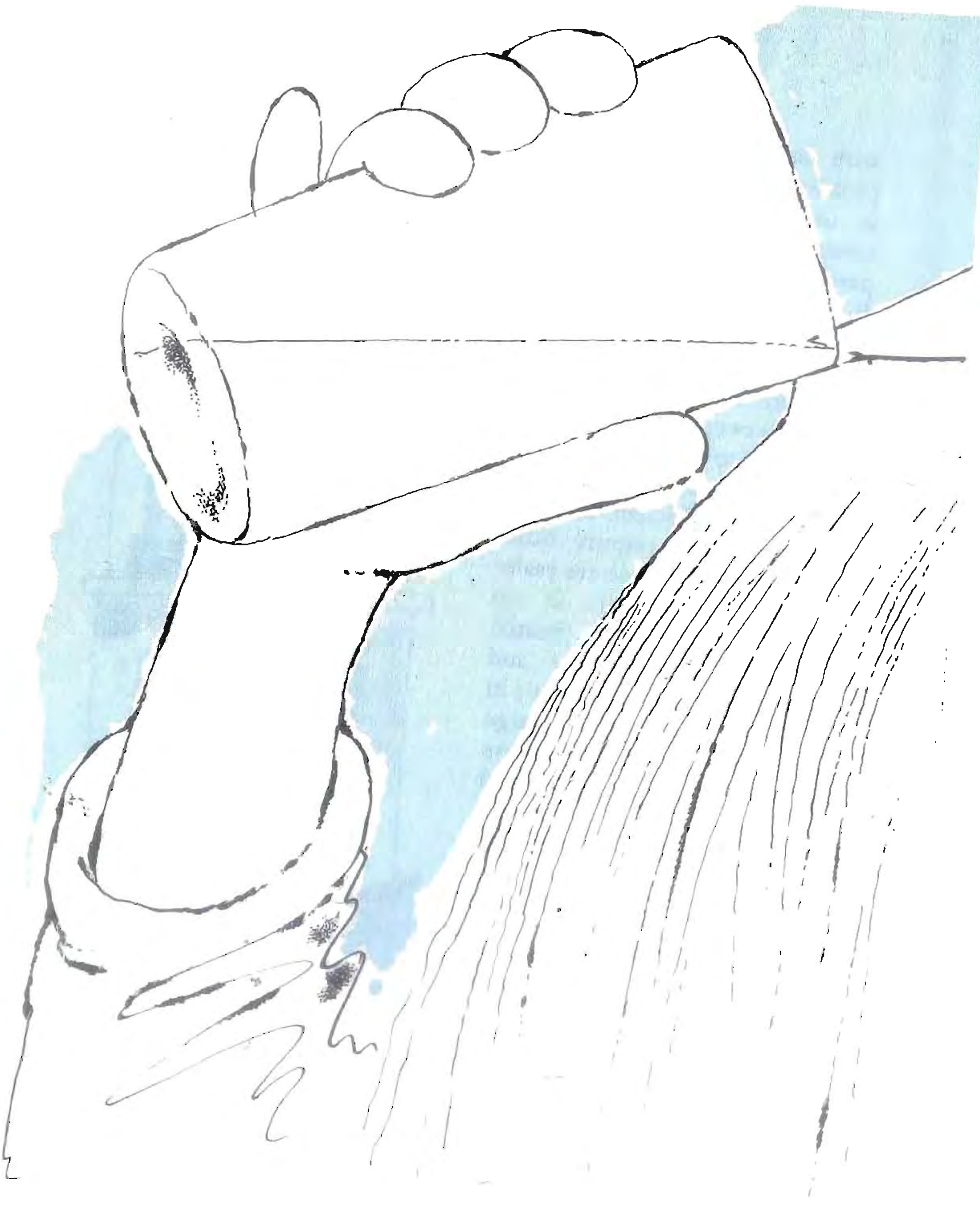
sea. But in India, the area covered by limestone is relatively small and is far from the sea. For the most part, we have no underground streams or underground water lakes. Our underground reservoirs of water are mostly in the pores of the soil or in the cracks of rocks. It is the water residing in the pores or cracks that we draw out by digging wells and tubewells.

The northern plains (Indus and Ganga valleys) are covered with thick alluvial soil which can store a large quantity of water in its pores. About ten to forty per cent of the volume of soil is empty pore space which water can fill while the amount of water that can be held in rock cracks and fissures is usually very small. About half of India is covered with basalts, granites and sedimentary rocks which can usually store only a small quantity of water, though it is often enough for our modest needs.

An individual cannot put a dam across a river or build a canal by himself but he can dig a well on his property and draw water for his crops. This form of irrigation is a great boon but it has its limitations.

If we pour water on the ground, it will seep into the soil. In the same way rainwater seeps into the soil. It has been observed that the water-level in wells rises after the rains. This shows that rainwater is the source of groundwater although a large portion of the rainwater that falls on the ground is transpirated from the topsoil, and only a fraction manages to percolate down to the water-table. It is this fraction that feeds our wells and tubewells. But if we keep drawing out excessive amounts of this water, the water-table will fall year after year. This is unfortunately happening in some pockets of our country. We can sometimes solve the problem by supplementing groundwater

with canal water. So far, the problem of a falling water-table is not widespread. On the contrary, there are many areas particularly in Uttar Pradesh, Bihar and Madhya Pradesh where we can safely draw much more groundwater than we are presently doing. In the next fifteen to twenty years it will be necessary to avail of all this untapped water if we hope to remain self-sufficient in food. Of course, we require other inputs also. But these are easier to develop. If there is no water, it cannot be created artificially, economically and this is a major limiting factor in the development of any large country. Our future appears bright as we are well endowed with this precious, all-important resource and merely need to harness it, which we are attempting to do and in which we are succeeding, too.



A DRINK THAT SATISFIES

When we are thirsty, we drink water. Water not only quenches our thirst but performs several other essential functions in our body. It collects toxins and expels them on its way out.

Since the water we drink is taken straight into the body, (unlike food which is first examined, sorted out, cooked and then eaten), its cleanliness is vital. It should be free of pathogens (disease-causing organisms), and should not contain excessive amounts of salts or toxic compounds. Many diseases, epidemics and even deaths are a result of drinking dirty water. Since our daily intake of water is quite small, it should not be difficult to arrange for a clean supply of drinking water. For cleaning, washing, bathing, livestock, etc. large amounts of water are not required.

VILLAGE WATER SUPPLY

A source of water, be it a well, pond, stream, spring, lake, canal, is usually found wherever there is human habitation, for, before deciding to settle anywhere, human beings first look for water nearby. This supply may, however, occasionally run dry due to lack of rain, and even drinking water may become scarce. Or the water that is available, may not be clean. People survive both these contingencies but they would certainly be far healthier if they had easy access to adequate amounts of clean water. There are about 600,000 villages in India, of which more than 100,000 face serious water shortages during summer, when the local sources dry up. In certain cases deep wells can be dug, but in others there is no easy solution. What, for instance, can one do for fifty families living on a hill slope or hill top?

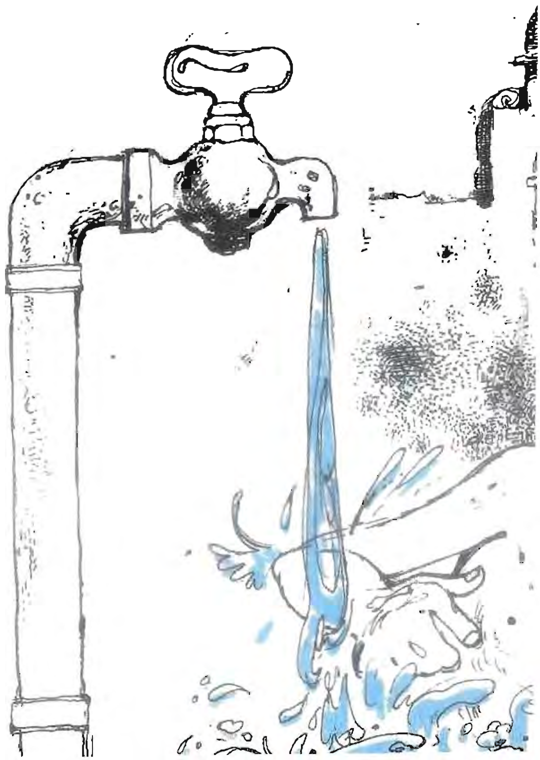
We get our drinking water from many sources; some good, some not so good, some bad, others downright dangerous. Distilled water, though the cleanest, is not good for drinking, as it tastes flat. So does rainwater, which also does not contain any dissolved minerals. But after rainwater passes over the soil or through it, it collects minerals and becomes good for drinking purposes. The problem sometimes is that it may become too salty to drink. The problem is worse if the salts are those of calcium or magnesium, for they make the water "hard", i.e., soap does not lather and when boiled, hard water leaves a deposit. It is very difficult to get rid of the salts altogether; distillation and reverse osmosis are rather expensive. But it is possible to remove harmful substances such as dust, soot and bacteria by filtering; and viruses can be killed by boiling.

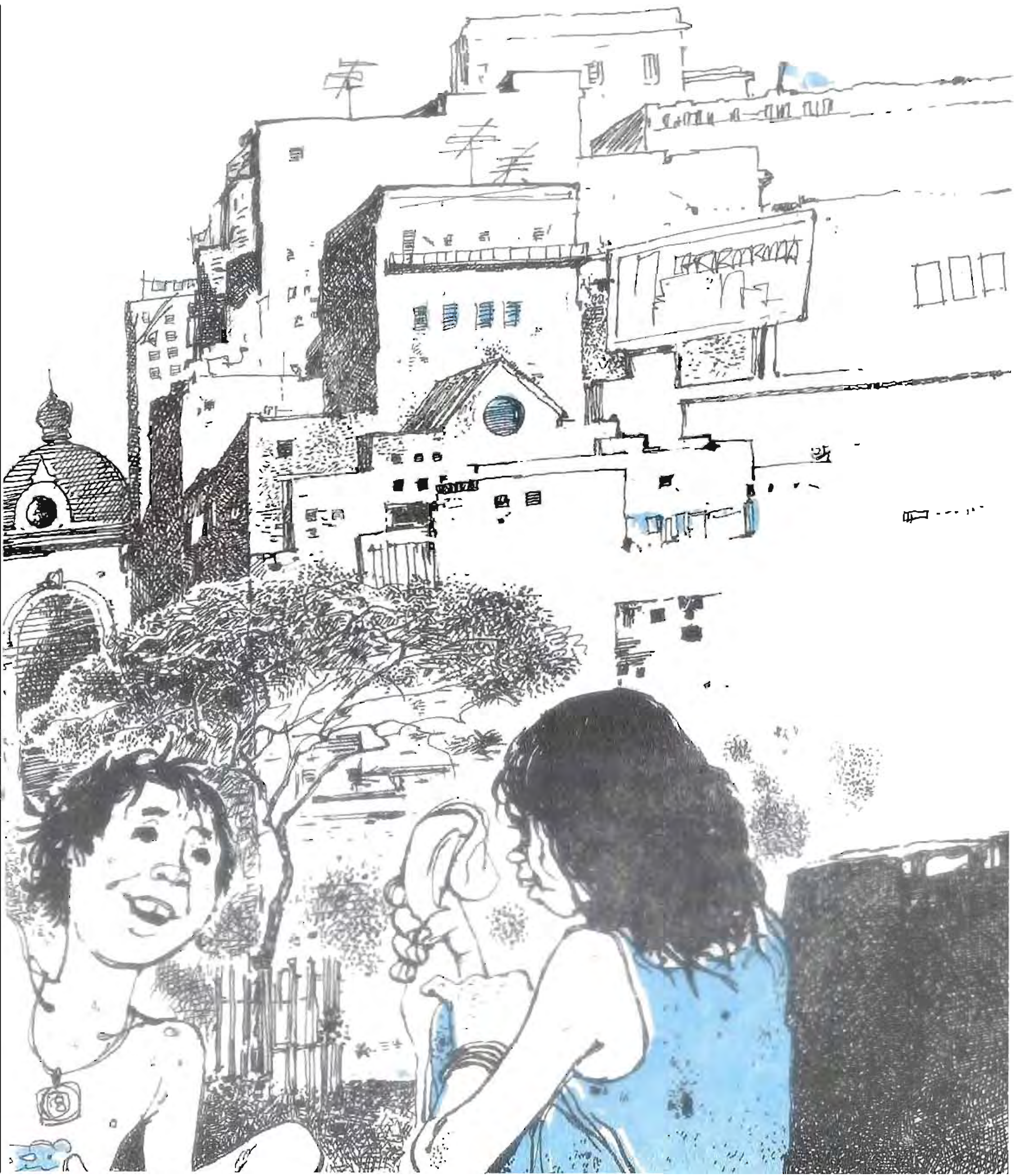
Groundwater, i.e. well water is naturally filtered in its passage through the soil and is usually clean. But we sometimes spoil even this supply. Covering wells, locating refuse dumps at a distance, directing sewage away and not allowing any cesspool close by are essential precautions. In some areas, hand pumps can be installed. These are easier to keep clean. Wherever open tanks are used to store water, water for drinking should be obtained from wells dug in the neighbourhood of the tank rather than directly from the tank.

In arid areas, there is no easy solution. The soil is usually very saline and so is the well water. People resort to using small tanks to store rainwater to tide over emergencies. In some areas, somewhat less saline water may be available deep underground. But the real answer is to impound flood waters in surplus regions and transfer it where and when it is needed. This is being attempted in the Thar desert in Rajasthan; water will be impounded in the Punjab and brought to Rajasthan by the Indira Canal.

CITY WATER SUPPLY

In big cities, a large number of people are packed into a limited space and often the locally available well water is not sufficient for their domestic

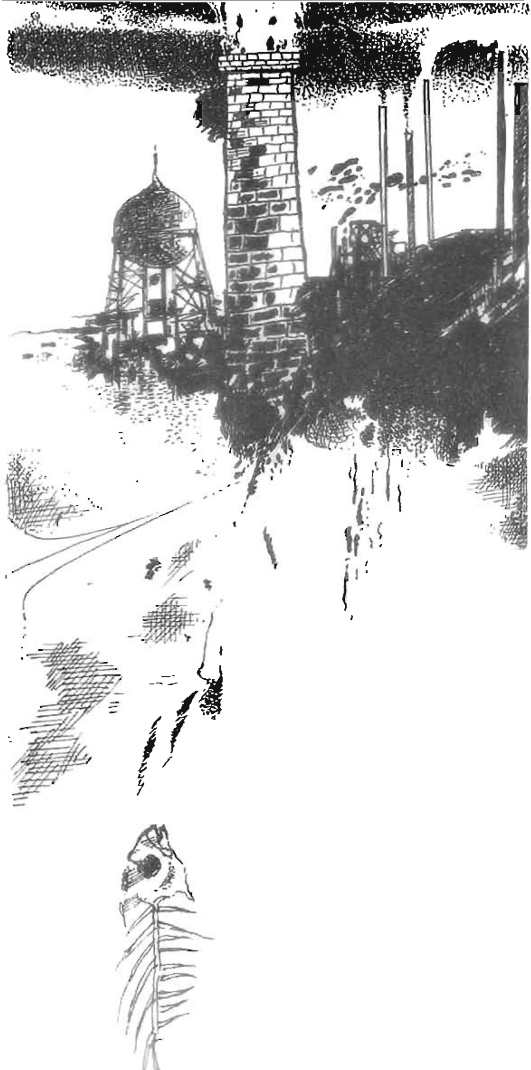


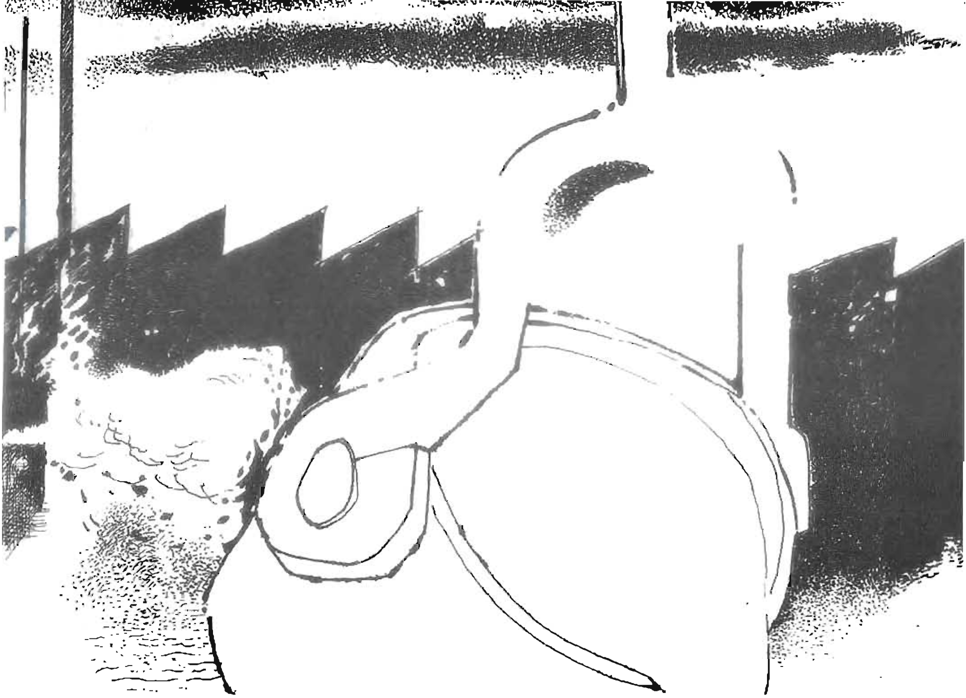


and industrial needs. Cities, therefore, import well or lake water from adjoining areas. Well water is usually put into our taps with little or no treatment but lake or river water is chlorinated to kill pathogens before it is piped, thus the quality of water in cities is different from that in villages.

In recent years, however, the population of our towns has increased so greatly that local and nearby sources of water have become insufficient and it has become necessary to import water from far off at considerable cost.

Another problem in cities is the disposal of sewage. Small cities sell it to farmers who grow vegetables on the outskirts of the town. This is unhygienic. Big cities try to remove the pathogens before channelling the sewage, usually into a stream, nullah or the sea. The treatment is rarely adequate, and we find that river water is highly polluted.





WATCH OUT

What is environmental degradation? It is such deterioration in the quality of the air, water, soil and plants that there is a risk to our health when we breathe, drink or eat. This excessive deterioration is a fairly recent phenomenon. Let us trace its origins.

Man's exploitation of nature started after he discovered fire, and began to use it for protection and cooking. But he began tapping nature's resources on a large scale only when he became an agriculturalist. To grow his food more efficiently and not depend on the vagaries of nature, he began to plough

and irrigate his fields. A reliable food supply liberated him to a great extent and gave him the leisure to indulge in other activities. He began to concentrate on producing goods for his greater comfort, convenience and entertainment. And he succeeded—perhaps too well.

Not very long ago the progress of a nation was judged by the quantity of coal it burnt, and the iron and other industrial goods it produced. It is only recently that it has been realized that relentlessly pursued such progress can ultimately cause more harm than good, not only to the surroundings, the environment such as the soil, air and water, but to man himself. This is because man is part of the environment and cannot set himself apart from it. There is a growing concern that man's unthinking despoiling of the environment has already started boomeranging on him. Consider the degradation of water.

ACID RAIN

It has been observed that in industrial countries rainfall has become acidic. In some cases the acidity is so great that rainwater tastes sour. This is because the two major fuels, coal and oil contain sulphur and when burnt in factories or for producing power, sulphur gets oxidized to become sulphur dioxide and appreciable

amounts of it are released into the atmosphere. Moreover, when oil is burnt in automobile engines, some of the nitrogen in the oil-air mixture when ignited gets oxidized to become nitrogen oxides. These sulphur and nitrogen oxides dissolve in cloud droplets and form sulphuric and nitric acids, making the very source of fresh water, rainwater, slightly acidic. This acidic rain damages life in lakes and not only affects soil, but worse, harms plants. Large areas of forest in West Germany and some in Sweden are thought to be affected by acid rain.

Though it is possible to control the release of acid-forming oxides, it is rather expensive. In India, this problem is not serious as yet because the sulphur content of our coal is low though it gives off too much ash and the amount of coal and oil being burnt is not very large for a country of our size. Some characteristics of our rainfall are also in our favour: our rainy season lasts only four months, during which the rains are heavy and frequent, and therefore, usually rather dilute in acids. For eight months there is basically no rain, and hence no acid rain either. The air carries the oxides to the sea. But we must be vigilant, and keep a watch on the levels of acidity in our rainwater.

ORGANIC CHEMICALS IN GROUNDWATER

There is another serious problem facing the world, again, more so the industrial world. Chemical industries have been dumping their waste materials in the ground. Though the soil is able to absorb large quantities of these, some seep into the groundwater and make it unfit for drinking and other domestic use. Similarly, some toxic materials escape from garbage dumps and pollute the groundwater below. Both these are, however, exam-

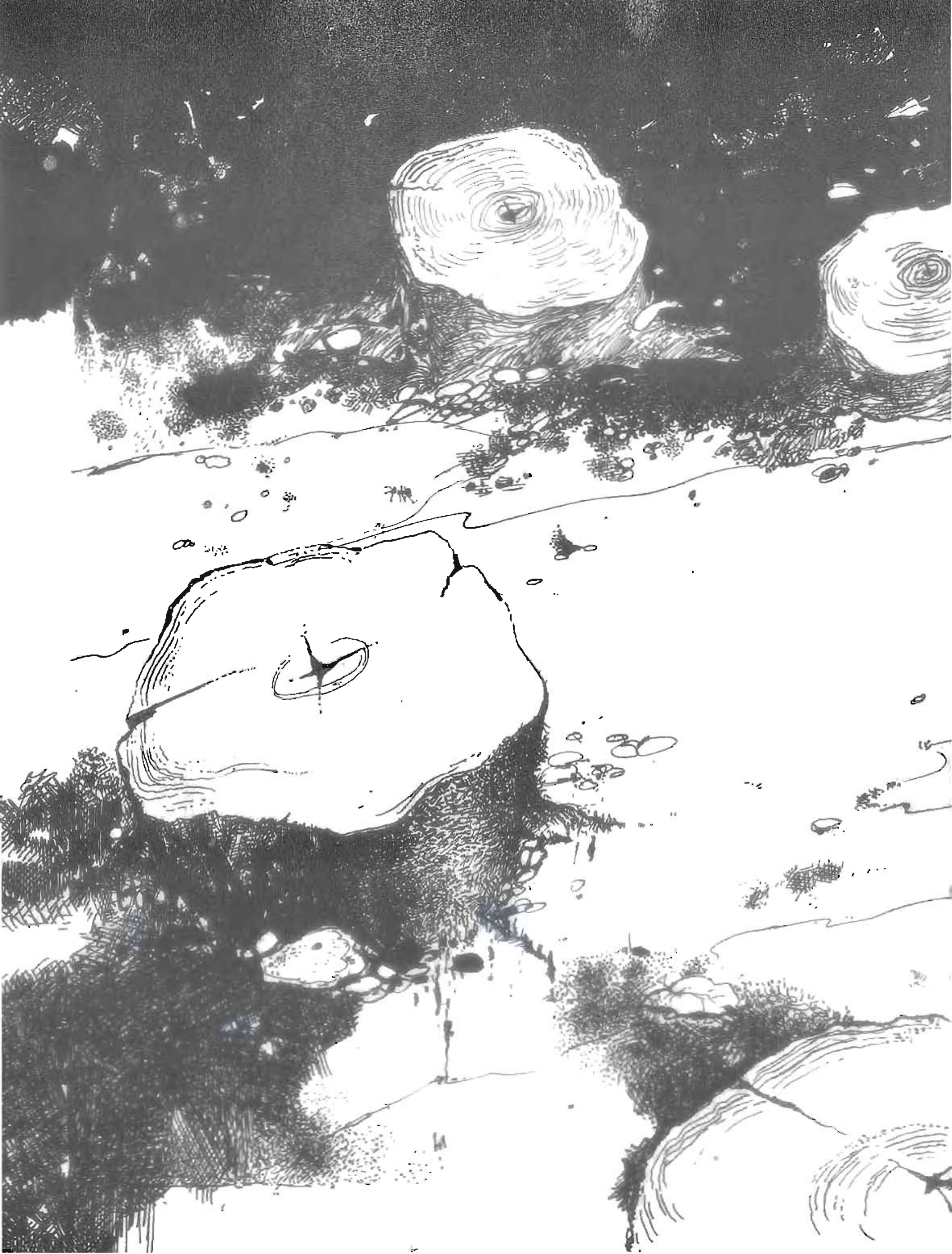
ples of local and removable sources of contamination of groundwater; but the damage caused by the other major offenders, pesticides and chemical fertilizers, which are being excessively used in agriculture, is far more widespread. And once contaminated, there is no practical way of cleansing groundwater.

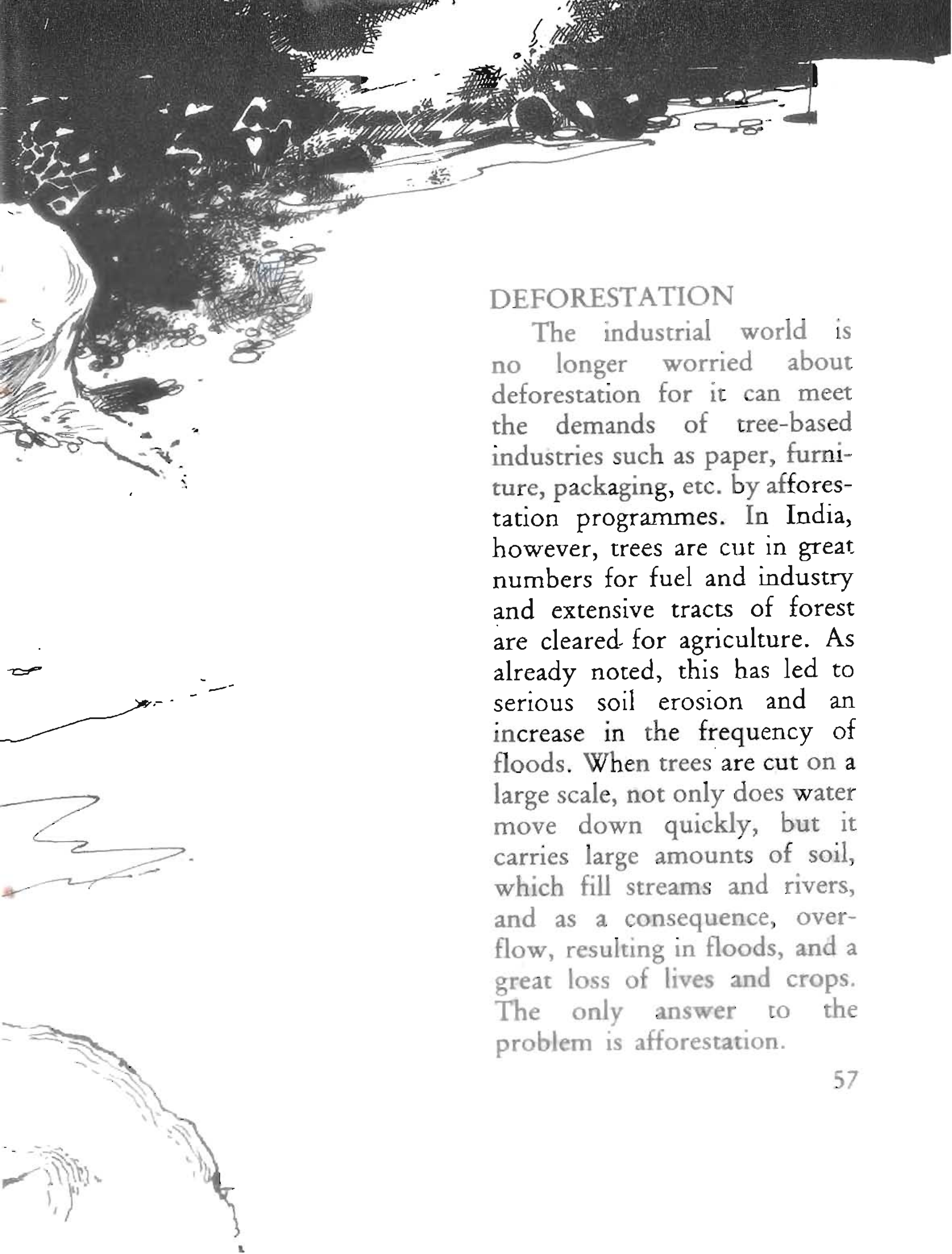
In India, both categories of pollutants exist but, as yet, on a relatively modest scale. Here too, we must remain vigilant and take remedial steps.

POLLUTED STREAM WATER

Industries release their wastes and towns their sewage into streams, polluting their waters. So the richer countries have been treating their industrial and domestic effluents before releasing them into streams. But in India we find this treatment expensive and it is only recently that realizing the gravity of the problem have we started clean-up operations.

Unfortunately pollution seems to be the price of industrial progress. People are now aware that they have to decide on their priorities—ultimately progress at an intolerable cost to the environment will be unacceptable.





DEFORESTATION

The industrial world is no longer worried about deforestation for it can meet the demands of tree-based industries such as paper, furniture, packaging, etc. by afforestation programmes. In India, however, trees are cut in great numbers for fuel and industry and extensive tracts of forest are cleared for agriculture. As already noted, this has led to serious soil erosion and an increase in the frequency of floods. When trees are cut on a large scale, not only does water move down quickly, but it carries large amounts of soil, which fill streams and rivers, and as a consequence, overflow, resulting in floods, and a great loss of lives and crops. The only answer to the problem is afforestation.

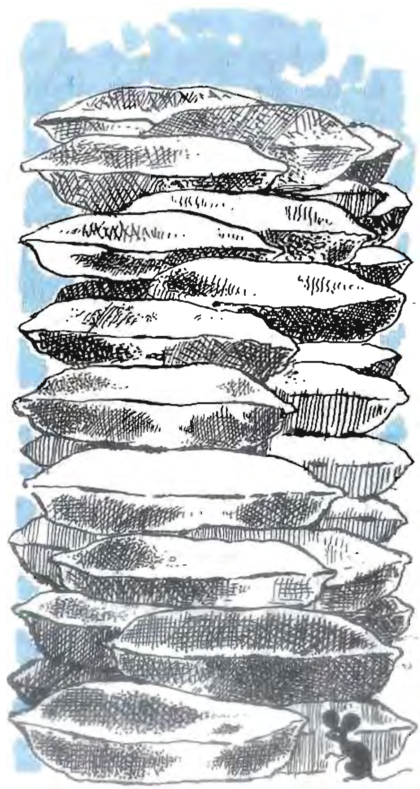
INTERFERENCE WITH NATURAL WATER CYCLE

No other nation has interfered with the water cycle to the extent that we have, and are continuing to do. Even if this has its drawbacks, we have no alternative at least for the next twenty or thirty years for, if we are to grow enough food for our increasing population, irrigation is essential. Irrigation means that water which would have normally gone to the sea is held back and given to plants, which breathe it out into the air as water vapour. Irrigation, therefore, modifies the natural water cycle, and is an interference with nature.

We have already built large-scale irrigation works and must expand them. But only to the extent that it appears advantageous because there are some visibly harmful effects of irrigation. Excessive use of canal water leads to excessive leakage which in turn makes the water-table rise. When it rises too

close to the surface, it may drown the roots of plants and hamper their growth. This is known as "water-logging". On the other hand, in an area where there is no canal, we have the tendency to draw out too much groundwater for irrigation, thus lowering the water table year after year. Therefore, both canal and groundwater irrigation should exist side by side, as in the Punjab. This has helped cope with the problem of water-logging.

The expansion of irrigation facilities is now being questioned on ecological grounds. When a dam is built across a stream to store flood water in the lake behind it, the pros and cons have to be weighed, the costs against benefits, and here there are serious differences of opinion. The major drawbacks of dams are: (i) the proposed artificial lake might cover substantial areas from where people have to be uprooted and

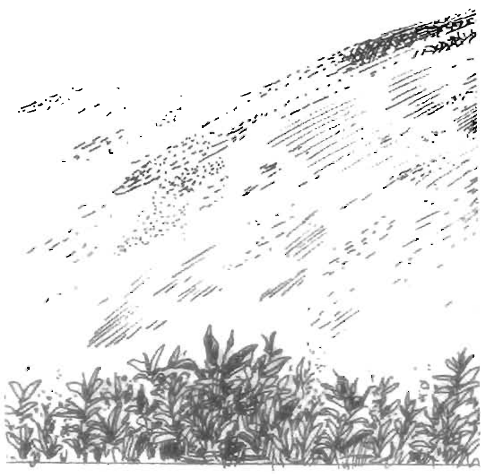


rehabilitated elsewhere; (ii) some agricultural land might be taken away by canals, distributaries, minor canals and water-courses; (iii) the trees in the area of the lake will be cut down; (iv) the seepage of water from the canals will cause water-logging in fields adjacent to the canals; (v) in addition there is the actual cost of materials and labour.

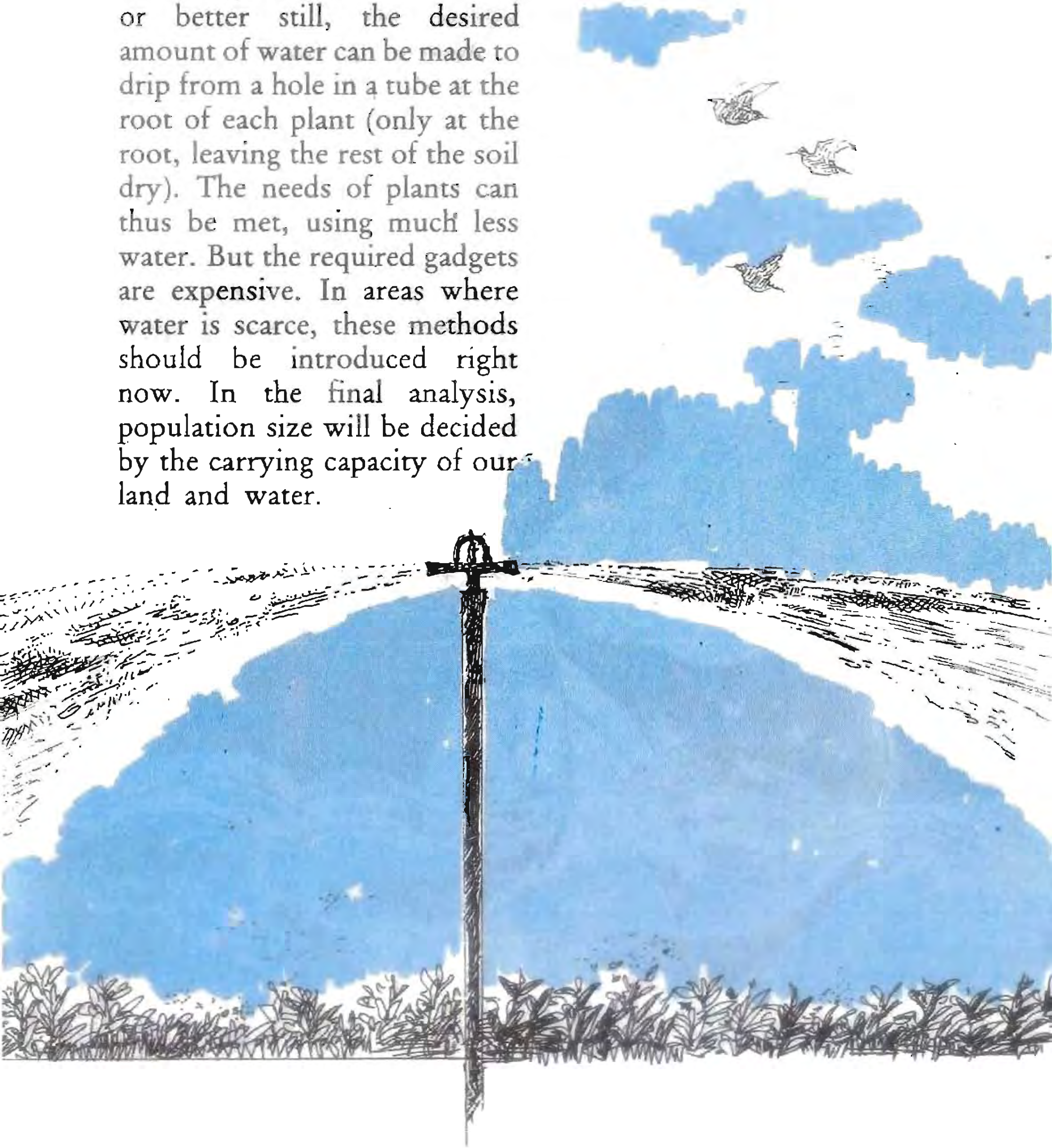
The main advantages are: (i) more and higher yielding crops; (ii) pollution-free hydro-electric power; (iii) flood control; (iv) employment for the masses.

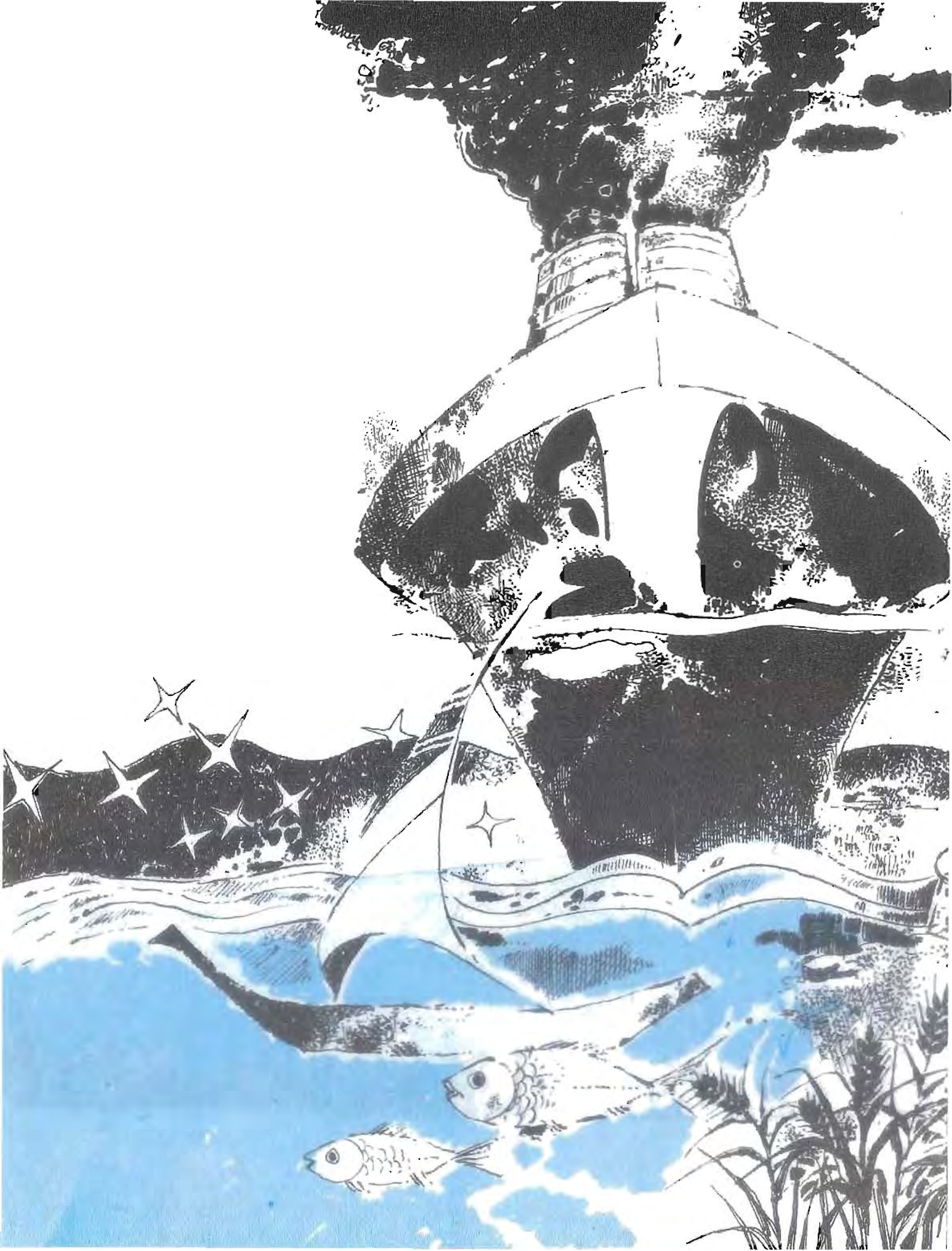
Ultimately, decision-makers are guided by immediate necessity and visible results. If more food is needed and irrigation is essential and also found economical, decisions go in favour of big dam projects; and possible long-term environmental damage is left to be tackled to such time that it becomes evident.

As long as our numbers keep increasing we cannot pause or turn back. Eventually, however, when there is less and less water to harness we will have to call a halt to building more irrigation projects. Then we have to resort to getting more out of existing facilities. One solution is to introduce sprinkler and drip irrigation. Normally when we irrigate a field, water flows from one end to the other, resulting in over-irrigation of those areas over which water flows for long periods and seeps down. This is wasteful. Water can be sprink-



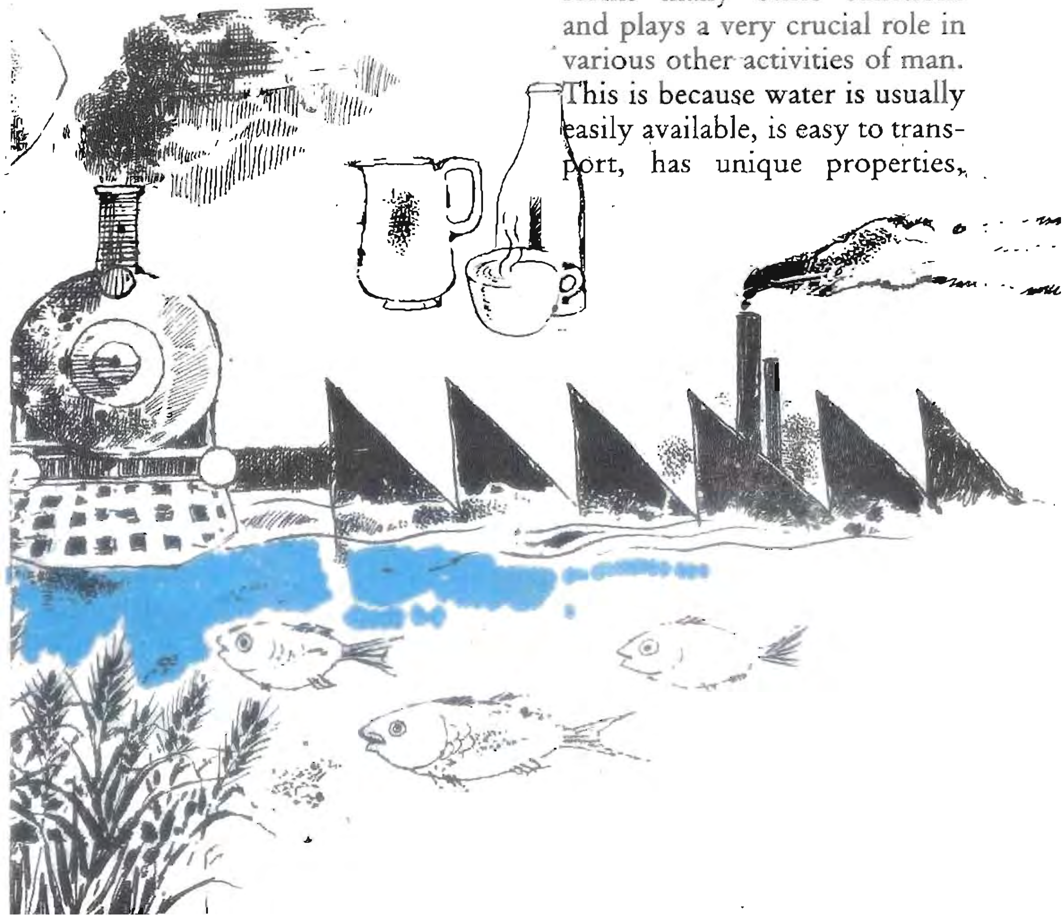
led evenly over the entire field or better still, the desired amount of water can be made to drip from a hole in a tube at the root of each plant (only at the root, leaving the rest of the soil dry). The needs of plants can thus be met, using much less water. But the required gadgets are expensive. In areas where water is scarce, these methods should be introduced right now. In the final analysis, population size will be decided by the carrying capacity of our land and water.





WATER IN MAN'S LIFE

We have been mainly looking at water in its role in growing plants which sustain life on earth. In India, this is its most important aspect but water performs many other functions and plays a very crucial role in various other activities of man. This is because water is usually easily available, is easy to transport, has unique properties,



and is the cheapest, and most valuable commodity on the earth.

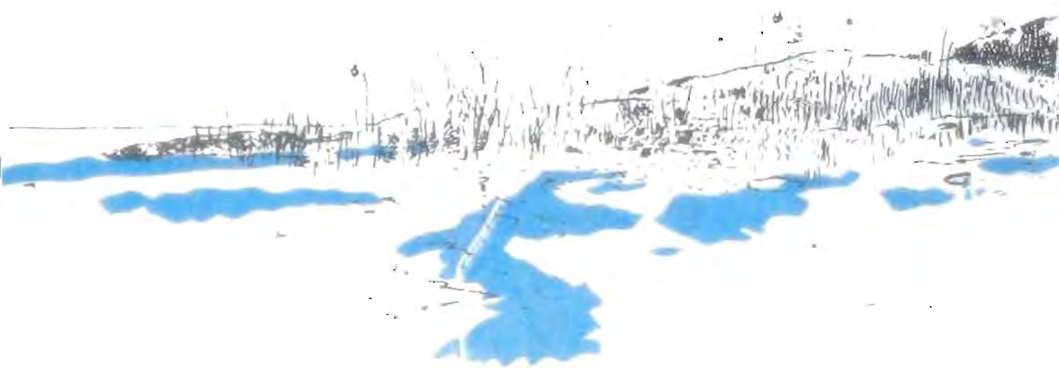
A moving body of water has considerable energy, which can be harnessed to produce electricity. This electric power is used for running hundreds of appliances that make life more comfortable.

Water is used in mining, in the manufacture of goods, in civil works, and in almost all industrial processes. In the industrial countries, the requirements of industry may even exceed those of irrigation.

Transporting goods over water is the cheapest mode of transport. That is why ships, despite their slow speed are used to take large bulky goods across the world's oceans. Some countries use their lakes, rivers and canals as highways to transport goods. In India too, we make good use of our waterways and long distances are covered in small boats and barges.

We have looked at the many uses of water but perhaps as important is the pleasure and enjoyment we derive from this precious natural resource. The tiny spring and the mighty river, the leaping waterfall and the immobile glacier all exert their particular charm and fill us with delight. Water also provides us with countless sources of recreation—paddling, swimming, sailing, fishing, rowing and skating.

Water is therefore not only essential for life but is an endless source of entertainment, recreation and joy.



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